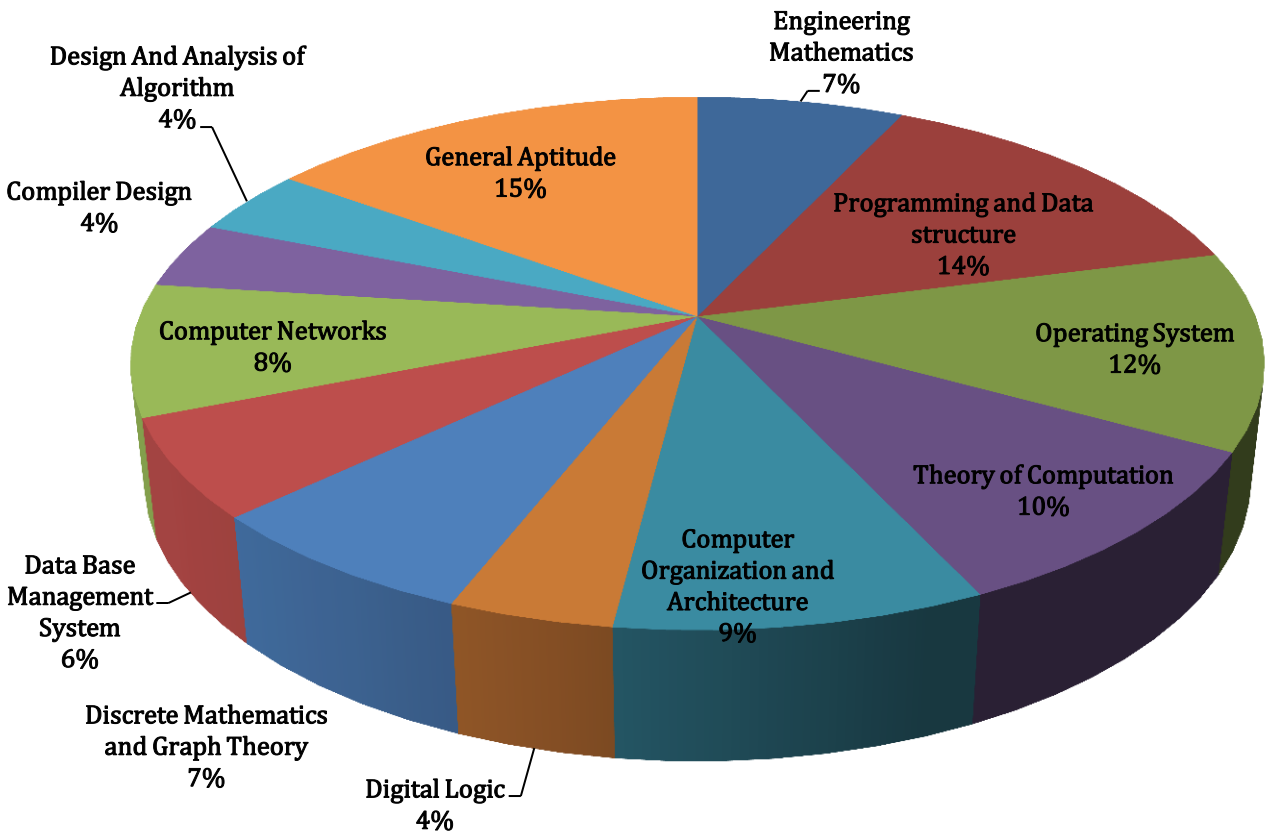
ANALYSIS OF GATE 2017*
Computer Science and Information Technology



CS ANALYSIS-2017_11-Feb_Morning

SUBJECT	Ques. No.	Topics Asked in Paper(Memory Based)	Level of Toughness	Total Marks
Engineering Mathematics	1 Marks: 1 2 Marks: 3	Linear algebra; Calculus	Medium	**7**
Programming and Data structure	1 Marks: 4 2 Marks: 5	Trees; Linked List; C-programming; Graph	Tough	**14**
Operating System	1 Marks: 2 2 Marks: 5	Threads; CPU Scheduling; Memory management; Deadlock/Thread	Easy	**12**
Theory of Computation	1 Marks: 2 2 Marks: 4	Context Free Grammar; Regular Expressions; Turing machine	Easy	**10**
Computer Organization and Architecture	1 Marks: 3 2 Marks: 3	Introduction; Instruction Set and Addressing Mode; Memory Hierarchy; Pipelining and Vector Processing	Medium	**9**
Digital Logic	1 Marks: 2 2 Marks: 1	Introduction; Boolean Algebra and Karnaugh Maps; Combinational and Sequential Digital Circuits	Easy	**4**
Discrete Mathematics and Graph Theory	1 Marks: 3 2 Marks: 2	Mathematical logic; Combinatorics	Easy	**7**
Data Base Management System	1 Marks: 2 2 Marks: 2	Functional Dependencies and Normalization; SQL; Relational Algebra & Relational Calculus; Transactions and Concurrency Control	Medium	**6**
Computer Networks	1 Marks: 2 2 Marks: 3	Network Security; TCP/IP, UDP and Sockets, IP(V4; Data link layer; Network Security	Easy	**8**
Compiler Design	1 Marks: 2 2 Marks:1	Parsing; Intermediate Code Generation	Easy	**4**
Design And Analysis of Algorithm	1 Marks: 2 2 Marks: 1	Algorithm analysis; Sorting Algorithm/Divide and conquer; Hashing	Medium	**4**
General Aptitude	1 Marks: 5 2 Marks: 5	Numerical Ability; Verbal Ability	Medium	**15**
Total	**65**			**100**
Faculty Feedback	Majority of the question were direct concept based. DS, OS, COA and TOC weightage was comparatively high. GA was medium as compared to the last year.			

GATE 2017 Examination

Computer Science and Information Technology

Test Date: 11/02/2017

Test Time: 9:00 AM to 12:00 PM

Subject Name: Computer Science and Information Technology

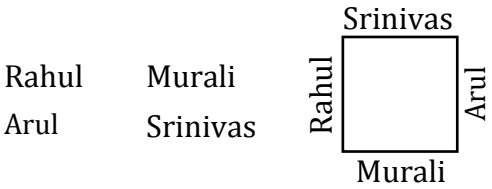
Section: General Aptitude

1. Rahul, Murali, Srinivas and Arul are seated around a square table. Rahul is sitting to the left of Murali. Srinivas is sitting to the right of Arul. Which of the following pairs are seated opposite each other?

(A) Rahul and Murali
(B) Srinivas and Arul
(C) Srinivas and Murali
(D) Srinivas and Rahul

[Ans. C]

From the given data, the following seated arrangement is possible around a square table.



∴ Srinivas and Murali are opposite to each other

2. Find the smallest number y such that y × 162 is a perfect cube.

(A) 24
(B) 27
(C) 32
(D) 36

[Ans. D]

Factorization of 162 is 2 × 3 × 3 × 3 × 3

y × 162 is a perfect cube

y × 2 × 3 × 3 × 3 × 3 = Perfect cube

2	162
3	81
3	27
3	9
	3

For perfect cube 2's and 3's are two more required each

i. e. , 2 × 2 × 2 × 3 × 3 × 3 × 3 × 3 × 3

y = 2 × 2 × 3 × 3 = 4 × 9 = 36

∴ The smallest number of y = 36

3. After Rajendra Chola returned from his voyage to Indonesia, he _____ to visit the temple in Thanjavur.

(A) was wishing
(B) is wishing
(C) wished
(D) had wished

[Ans. C]

If the main clause is in the past the past tense, the subordinate clause also should be in the past tense.

4. Research in the workplace reveals that people work for many reasons _____.

(A) money beside
(B) beside money
(C) money besides
(D) besides money

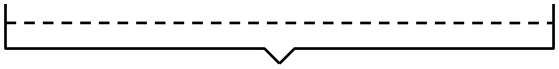
[Ans. D]

'Besides' means in addition to.

5. The probability that a k-digit number does NOT contain the digits 0, 5, or 9 is

(A) 0.3^k
(B) 0.6^k
(C) 0.7^k
(D) 0.9^k

[Ans. C]



Each digit can be filled in 7 ways as 0, 5 and 9 is not allowed so, each of these places can be filled by 1, 2, 3, 4, 5, 6, 8.

So, required probability $= \left(\frac{7}{10}\right)^k = (0.7)^k$

6. The expression $\frac{(x+y)-|x-y|}{2}$ is equal to

(A) The maximum of x and y
(B) The minimum of x and y
(C) 1
(D) None of the above

[Ans. B]

$\frac{(x+y)+|x-y|}{2} \ldots\ldots\ldots (1)$

$|x-y| = \pm(x-y), \text{if}(x-y) \text{ when } x > y$

$\text{if} -(x-y) = (y-x) \text{when } y > x$

$\frac{(x+y)+(x-y)}{2} = \frac{x+y-x+y}{2}$

$= \frac{2y}{2} = y$

$= \text{minimum of } (x, y)$

as $(x > y)$

$\frac{(x+y)+(y-x)}{2} = \frac{x+y-y-x}{2}$

$= \frac{2x}{2} = x$

$= \text{minimum of } (x, y)$

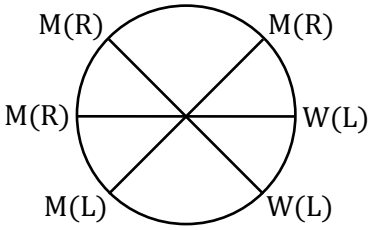
as $x < y$

7. Six people are seated around a circular table. There are at least two men and two women. There are at least three right-handed persons. Every woman has a left-handed person to her immediate right. None of the women are right-handed. The number of women at the table is

(A) 2
(B) 3
(C) 4
(D) Cannot be determined

[Ans. A]

The total Number of peoples are sitting around a circular table is 6, in which atleast 2 men, atleast 2 women and atleast three right handed persons are compulsory. From this data, the following circular form is possible.



M = Male
W = Women
L = Left hand
R = Right hand
∴ The number of women on the table is 2.

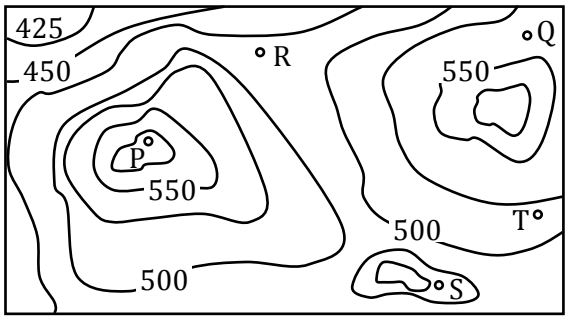
8. "The hold of the nationalist imagination on our colonial past is such that anything inadequately or improperly nationalist is just not history."
Which of the following statements best reflects the author's opinion?

(A) Nationalists are highly imaginative
(B) History is viewed through the filter of nationalism
(C) Our colonial past never happened
(D) Nationalism has to be both adequately and properly imagined

[Ans. B]

To refer is to reach an opinion. The right opinion of the author is 'History is viewed through the filter of nationalism'. So, option B is the right opinion of the author. The key words in the statement are 'history and nationalist imagination'.

9. A contour line joins locations having the same height above the mean sea level. The following is a contour plot of a geographical region. Contour lines are shown at 25 m intervals in this plot. If in a flood the water level rises to 525 m, which of the villages P, Q, R, S, T get submerged?



(A) P, Q
(B) P, Q, T
(C) R, S, T
(D) Q, R, S

[Ans. C]

The given contour is a hill station, the peak point of this hill station is P, it is under a contour of 550. At floods, the water level is 525 m. So, the village of R, S and T are under a contour of 500. Therefore these villages are submerged.

10. Arun, Gulab, Neel and Shweta must choose one shirt each from a pile of four shirts coloured red, pink, blue and white respectively. Arun dislikes the colour red and Shweta dislike the colour white. Gulab and Neel like all the colours. In how many different ways can they choose the shirts so that no one has a shirt with a colour he or she dislikes?

(A) 21
(B) 18
(C) 16
(D) 14

[Ans. D]

Persons are Arun, Gulab, Neel and Shweta shirt colours are red, pink, blue and white

→ Arun dislike red colour means he like remaining three other colours

→ Shweta dislike white colour means he like remaining three other colours

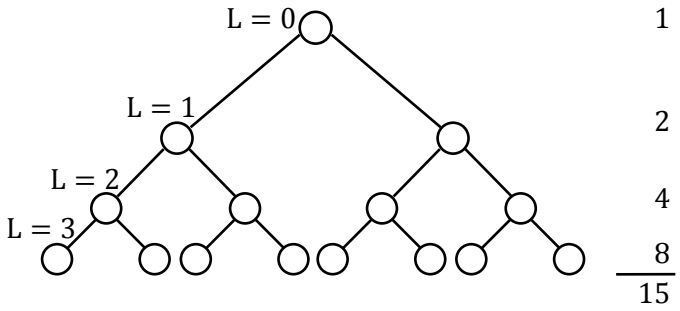
→ Gulab and Neel are likes all the four colours

→ The total Number of ways to choose shifts $= 3 + 3 + 4 + 4 = 14$

Section: Technical

1. Let $c_1, \ldots, c_n$ be scalars, not all zero, such that $\sum_{i=1}^{n} c_i a_i = 0$ where a_i are column vectors in R^{11}. Consider the set of linear equations
$Ax = b$
Where $A = [a_1, \ldots, a_n]$ and $b = \sum_{i=1}^{n} a_i$. The set of equations has
(A) a unique solution at $x = J_n$ where J_n denotes a n-dimensional vector of all 1
(B) no solution
(C) infinitely many solutions
(D) finitely many solutions
[Ans. C]
The vectors $a_1, a_2, \ldots, a_n$ are linearly dependant.
For the system $AX = B$,
Rank of coefficient matrix A = Rank of augmented matrix (A/ B)
$= k\ (k < n)$
∴ The system has infinitely many solutions

2. Let T be a binary search tree with 15 nodes. The minimum and maximum possible heights of T are:
Note: The height of a tree with a single node is 0.
(A) 4 and 15 respectively
(B) 3 and 14 respectively
(C) 4 and 14 respectively
(D) 3 and 15 respectively
[Ans. B]



Minimum = 3, Maximum = 14

3. When two 8-bit numbers $A_7 \ldots A_0$ and $B_7 \ldots B_0$ in 2's complement representation (with A_0 and B_0 as the least significant bits) are added using a ripple-carry adder, the sum bits obtained are $S_7 \ldots S_0$ and the carry bits are $C_7 \ldots C_0$. An overflow is said to have occurred if
(A) the carry bit C_7 is 1
(B) all the carry bits ($C_7 \ldots C_0$) are 1
(C) $(A_7 . B_7 . \overline{S}_7 + \overline{A}_7 . B_7 . S_7)$ is 1
(D) $(A_0 . B_0 . \overline{S}_0 + \overline{A}_0 . \overline{B}_0 . S_0)$ is 1
[Ans. C]
$A_7\ A_6\ A_5\ A_4\ A_3\ A_2\ A_1\ A_0$
$B_7\ B_6\ B_5\ B_4\ B_3\ B_2 B_1\ B_0$
$C_6\ C_5\ C_4\ C_3\ C_2\ C_1\ C_0$
$C_7\ S_7 S_6\ S_5\ S_4\ S_3\ S_2\ S_1\ S_0 \rightarrow$ Result
Overflow occurs, when S_7 is '0' while adding 2 numbers of negative data or S_7 is '1' while adding 2 numbers of positive data.
Expression is $A_7\ B_7\ \overline{S}_7 + \overline{A}_7\ \overline{B}_7\ S_7$

4. Let T be a tree with 10 vertices. The sum of the degree of all the vertices in T is _____.

[Ans. *] Range: 18.0 to 18.0

If T has n vertices, then number of edges in T is $n - 1$

By sum of degrees of vertices theorem

$$\sum_{i=1}^{10} \deg\ (V_i) = 2\ |E| = 2(9) = 18$$

5. Consider the following functions from positive integers to real numbers:

$10, \sqrt{n}, n, \log_2 n, \frac{100}{n}$

The CORRECT arrangement of the above functions in increasing order of asymptotic complexity is

(A) $\log_2 n, \frac{100}{n}, 10, \sqrt{n}, n$

(B) $\frac{100}{n}, 10, \log_2 n, \sqrt{n}, n$

(C) $10, \frac{100}{n}, \sqrt{n}, \log_2 n, n$

(D) $\frac{100}{n}, \log_2 n, 10, \sqrt{n}, n$

[Ans. B]

As $n \to \infty, \frac{100}{n} < 10 < \log_2 n < \sqrt{n} < n$

6. Consider the C code fragment given below.

```
typedef struct node
{
    int data;
    node * next;
} node;
void join (node * m, node * n)
{
    node * p = n;
    while (p → next ! = NULL)
    {
        p = p → next;
    }
    p → next = m;
}
```

Assuming that m and n point to valid NULL-terminated linked lists, invocation of join will

(A) Append list m to the end of list n for all inputs.

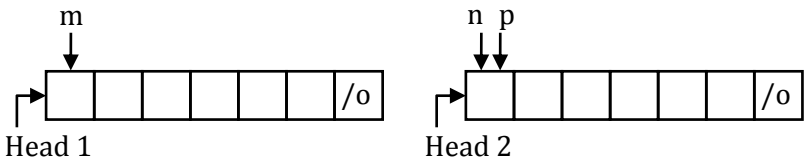
(B) Either cause a null pointer dereference or append list m to the end of list n.

(C) Cause a null pointer dereference for all inputs.

(D) Append list n to the end of list m for all inputs.

[Ans. B]

Consider two linked lists:



After the code execution, list 'm' will be appended to the end of list 'n'. But in some cases it can cause a null pointer dereference also.

7. The n-bit fixed-point representation of an unsigned real number X uses f bits for the fraction part. Let $i = n - f$. The range of decimal values for X in this representation is

(A) 2^{-r} to 2^{f}
(B) 2^{-f} to $(2^{f} - 2^{-f})$
(C) 0 to 2^{f}
(D) 0 to $(2^{f} - 2^{-f})$

[Ans. D]

Real number size is n bits.
Type of data is unsigned
Fraction part size = f bits
Integer part size = $(n - f)$ bits
Range of the Decimal values for only integer part is $(0 \text{ to } 2^{i} - 1)$
Range of the Decimal values for only fraction part is $\left(0 \text{ to } \left(1 - 2^{-f}\right)\right)$
Range of the Real number is 0 to $(2^{i} - 1 + 1 - 2^{-f})$
$= 0 \text{ to } (2^{i} - 2^{-f})$

8. The statement $(\neg p) \Rightarrow (\neg q)$ is logically equivalent to which of the statements below?

I. $p \Rightarrow q$
II. $q \Rightarrow p$
III. $(\neg q) \vee p$
IV. $(\neg p) \vee q$

(A) I only
(B) I and IV only
(C) II only
(D) II and III only

[Ans. D]

$(\sim p \Rightarrow \sim q)$
$\Leftrightarrow (q \Rightarrow p)$(By contrapositive equivalence)
$\Leftrightarrow (\sim q \vee p)\left(\because (a \to b) \equiv (\sim a \vee b)\right)$

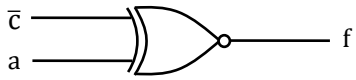
9. Consider the Karnaugh map given below, where X represents "don't care" and blank represents 0.

ba / dc	00	01	11	10
00		x	x	
01	1			x
11	1			1
10		x	x	

Assume for all inputs (a, b, c, d), the respective complements $(\bar{a}, \bar{b}, \bar{c}, \bar{d})$ are also available. The above logic is implemented using 2-input NOR gates only. The minimum number of gates required is _____.

[Ans. *] Range: 1.0 to 1.0

$c\bar{a} = \bar{\bar{c}}\bar{a} = \overline{\bar{c} + a}$



Hence, only one NOR gate is sufficient.

10. Threads of a process share

(A) global variables but not heap
(B) heap but not global variables
(C) neither global variables nor heap
(D) both heap and global variables

[Ans. D]

Threads of a process share code section, data section (global variables) and heap but not stack and registers.

11. The following functional dependencies hold true for the relational schema R{V, W, X, Y, Z}:

V → W
VW → X
Y → VX
Y → Z

Which of the following is irreducible equivalent for this set of functional dependencies?

(A) V → W
V → X
Y → V
Y → Z

(B) V → W
W → X
Y → V
Y → Z

(C) V→ W
V → X
Y → V
Y → X
Y → Z

(D) V → W
W → X
Y → V
Y → X
Y → Z

[Ans. A]

As V → W, delete W from VW → X results in V → X
As V → X, delete X from Y → VX results in Y → V
The irreducible set is
V → W
V → X
Y → V
Y → Z

12. Consider a database that has the relation schema EMP (EmpID, EmpName, and DeptName). An instance of the schema EMP and a SQL query on it are given below.

EMP		
EmpID	EmpName	DeptName
1	XYA	AA
2	XYB	AA
3	XYC	AA
4	XYD	AA
5	XYE	AB
6	XYF	AB
7	XYG	AB
8	XYH	AC
9	XYI	AC
10	XYJ	AC
11	XYK	AD
12	XYL	AD
13	XYM	AE

```
SELECT AVG(EC.Num)
FROM EC
WHERE (DeptName, Num) IN
    (SELECT DeptName, COUNT(EmpId) AS
                              EC(DeptName,Num)
    FROM EMP
    GROUP BY DeptName
```

The output of executing the SQL query is _____.

[Ans. *] Range: 2.6 to 2.6

Result of inner query

Dept name	Number
AA	4
AB	3
AC	3
AD	2
AE	1

Result of outer query $= \frac{13}{5} = 2.6$

13. Consider the first-order logic sentence F: $\forall x(\exists y R(x, y))$. Assuming non-empty logical domain, which of the sentences below are implied by F?

I. $\exists y(\exists x R(x, y))$
II. $\exists y(\forall x R(x, y))$
III. $\forall y(\exists x R(x, y))$
IV. $\neg\exists x(\forall y \neg R(x, y))$

(A) IV only
(B) I and IV only
(C) II only
(D) II and III only

[Ans. B]

We have $\forall_x \left(\exists_y R(x, y)\right) \Rightarrow \exists_y (\exists_x R(x, y))$

And $\forall_x(\exists_y R(x,y)) \Leftrightarrow \sim\exists_x(\forall_x \sim R(x,y))$
$\therefore$ The formulas I and IV are implied by F

14. Consider the following grammar:
P → xQRS
Q → yz | z
R → w | ε
S → y
What is FOLLOW(Q)?
(A) {R}
(B) {w}
(C) {w, y}
(D) {w, $}
[Ans. C]
FOLLOW (Q) = First (R) − {ε} ∪ First (S)
= {w, ε} − {ε} ∪ {y} = {w, y}

15. Consider the following context-free grammar over the alphabet $\sum = \{a, b, c\}$ with S as the start symbol:
S → abScT | abcT
T → bT | b
Which one of the following represents the language generated by the above grammar?
(A) $\{(ab)^n(cb)^n | n \geq 1\}$
(B) $\{(ab)^n\, cb^{m_1}\, cb^{m_2} \ldots cb^{m_n} | n, m_1, m_2, \ldots, m_n \geq 1\}$
(C) $\{(ab)^n(cb^m)^n | m, n \geq 1\}$
(D) $\{(ab)^n\, (cb^n)^m | m, n \geq 1\}$
[Ans. B]
The given Grammar over Σ = {a, b, c} with S as the start symbol is
S → abScT | abcT
T → bT | b
The minimum length string generated by the grammar is 1:
S → abcT → abcb; hence all variable greater than 1
Other cases
S → abScT → ab abScT cT → ab ab abScT cT cT → ⋯ → $(ab)^n\,(cT)^n$
Here T can generate any number of b's starting with single b
Hence, The language is $L = \{(ab)^n \ldots cb^{m_1}\, cb^{m_2}\, cb^{m_3}\, cb^{m_4} \ldots cb^{m_n} | m_1, m_2, m_3, m_4 \ldots m_n\ n \geq 1\}$

16. Consider the C struct defined below:

```
struct data
{
    int marks [100];
    char grade;
    int cnumber;
};
struct data student;
```

The base address of student is available in register R1. The field student.grade can be accessed efficiently using

(A) Post-increment addressing mode, (R1) +
(B) Pre-decrement addressing mode, −(R1)
(C) Register direct addressing mode, R1
(D) Index addressing mode. X(R1), where X is an offset represented in 2's complement 16-bit representation.

[Ans. D]

While finding the grade of the student, it adds the displacement value to the Roll number of the student.

Hence, it is Index Addressing mode.

17. Consider the following intermediate program in three address code

$p = a - b$
$q = p * c$
$p = u * v$
$q = p + q$

Which one of the following corresponds to a static single assignment form of the above code?

(A) $p_1 = a - b$
$q_1 = p_1 * c$
$p_1 = u * v$
$q_1 = p_1 + q_1$

(B) $p_3 = a - b$
$q_4 = p_3 * c$
$p_4 = u * v$
$q_5 = p_4 + q_4$

(C) $p_1 = a - b$
$q_1 = p_2 * c$
$p_3 = u * v$
$q_2 = p_4 + q_3$

(D) $p_1 = a - b$
$q_1 = p * c$
$p_2 = u * v$
$q_2 = p + q$

[Ans. B]

All assignments in SSA are to variables with distinct names

$p_3 = a - b$
$q_4 = p_3 * c$
$p_4 = u * v$
$q_5 = p_4 + q_4$

18. Consider the following CPU processes with arrival times (in milliseconds) and length of CPU bursts (in milliseconds) as given below:

Process	Arrival time	Burst time
P1	0	7
P2	3	3
P3	5	5
P4	6	2

If the pre-emptive shortest remaining time first scheduling algorithm is used to schedule the processes, then the average waiting time across all processes is _____ milliseconds

[Ans. *] Range: 3.0 to 3.0

Gantt Chart:

P1	P2	P4	P1	P3

0 3 6 8 12 17

Process	Arrival Time (AT)	Burst Time (BT)	Compilation Time (CT)	Turn Around Time (Compilation Time – Arrival Time)	Waiting Time (TAT – BT)
P1	0	7	12	12	5
P2	3	3	6	3	0
P3	5	5	17	12	7
P4	6	2	8	2	0
					Total = 12

Average Waiting Time $= \frac{12}{4} = 3$

19. A sender S sends a message m to receiver R, which is digitally signed by S with its private key. In this scenario, one or more of the following security violations can take place.

I. S can launch a birthday attack to replace m with a fraudulent message.
II. A third party attacker can launch a birthday attack to replace m with a fraudulent message.
III. R can launch a birthday attack to replace m with a fraudulent message.

Which of the following are possible security violations?

(A) I and II only
(B) I only
(C) II only
(D) II and III only

[Ans. B]

Sender can launch a Birthday Attack to replace with fraudulent message, because he has the signature and he can decrypt the signature by his own public key and gets the hash value. With that same hash value, he can create another message and can be sent instead of original. Hence option (B) is correct.

20. Consider the following table:

Algorithms	Design Paradigms
P. Kruskal Q. Quicksort R. Floyd-Warshall	i. Divide and Conquer ii. Greedy iii. Dynamic Programing

Match the algorithms to the design paradigms they are based on.

(A) P - ii, Q - iii, R - i
(B) P - iii, Q - i, R - ii
(C) P - ii, Q - i, R - iii
(D) P - i, Q - ii, R - iii

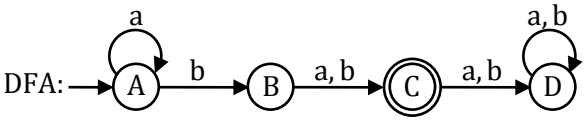
[Ans. C]

21. Consider the language L given by the regular expression $(a + b)^*b(a + b)$ over the alphabet {a, b}. The smallest number of states needed in a deterministic finite-state automaton (DFA) accepting L is _____

[Ans. *] Range: 4.0 to 4.0

$r = (a + b)^*b\,(a + b)$

$L = (a + b)^*(ba + bb)$



L contains strings with length atleast 2 but ends in ba or bb

All the states of DFA are distinct and all the states are reachable
∴ Number of states in MDFA that Accepts L = 4

22. Consider a two-level cache hierarchy with L_1 and L_2 caches. An application incurs 1.4 memory accesses per instruction on average. For this application, the miss rare of L_1 cache is 0.1; the L_2 cache experiences, on average, 7 misses per 1000 instructions. The miss rate of L_2 expressed correct to two decimal places is _____.

[Ans. *] Range: 0.05 to 0.05

On Average, 1.4 memory accesses are required for one instruction execution on average. So, for 1000 instructions 1400 Accesses are needed.

Number of misses occurred in cache L_2 for 1000 instruction = 7/1400 = 0.005

∴ Missrate of L_2 cache $= \frac{\text{misses in } L_2 \text{ cache}}{\text{missrate in } L_1 \text{cache}} = \frac{0.005}{0.1} = 0.05$

23. Consider a TCP client and a TCP sever running on two different machines. After completing data transfer, the TCP client calls close to terminate the connection and a FIN segment is sent to the TCP server. Server-side TCP responds by sending an ACK, which is received by the client-side TCP. As per the TCP connection state diagram (RFC 793), in which state does the client-side TCP connection wait for the FIN from the server-side TCP?

(A) LAST-ACK
(B) TIME-WAIT
(C) FIN-WAIT-1
(D) FIN-WAIT-2

[Ans. D]

24. Consider the following C code:

```
#include <stdio.h>
int *assignval (int *x, int val)
{
    *x = val;
    return x;
}
void main ( )
{
    int *x = malloc (sizeof (int));
    if (NULL = = x) return;
    x = assignval (x, 0);
    if (x)
    {
        x = (int *) malloc (sizeof (int));
        if (NULL = = x) return;
        x = assignval (x, 10);
    }
    printf("%d\n", *x);
    free (x) ;
}
```

The code suffers from which one of the following problems:
(A) compiler error as the return of malloc is not typecast appropriately
(B) compiler error because the comparison should be made as x = = NULL and not as shown
(C) compiles successfully but execution may result in dangling pointer
(D) compiles successfully but execution may result in memory leak
[Ans. A]

25. Let X be a Gaussian random variable with mean 0 and variance σ^2. Let Y = max(X, 0) where max(a, b) is the maximum of a and b. The median of Y is _____.
[Ans. *] Range: 0.0 to 0.0
Here, half of the values of Y are to the left of the mean X = 0 and the remaining half of the values of Y lies to the right of the mean X = 0
∴ The median of Y = 0

26. Consider a 2-way set associative cache with 256 blocks and uses LRU replacement. Initially the cache is empty. Conflict misses are those misses which occur due to contention of multiple blocks for the same cache set. Compulsory misses occur due to first time access to the block. The following sequence of accesses to memory blocks (0, 128, 256, 128, 0, 128, 256, 128, 1, 129, 257, 129, 1, 129, 257, 129) is repeated 10 times. The number of conflict misses experienced by the cache is _____.
[Ans. *] Range: 76.0 to 76.0
A miss is not considered a conflict miss if the block is accessed for the first time.
1st round: (2 + 2) misses
2nd round: (4 + 4) misses
∴ Total = 4 + (8 × 9) = 76 conflict misses

27. Let A be an array of 31 numbers consisting of a sequence of 0's followed by a sequence of 1's. The problem is to find the smallest index i such that A[i] is 1 by probing the minimum number of locations in A. The worst case number of probes performed by an optimal algorithm is _____.
[Ans. *] Range: 5.0 to 5.0
Since n = 31 = $2^5 - 1$
By using optimal searching algorithm it takes in worst case '5' comparison.

28. Instruction execution in a processor is divided into 5 stages. Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Execute (EX), and Write Back (WB). These stages take 5, 4, 20, 10, and 3 nanoseconds (ns) respectively. A pipelined implementation of the processor requires buffering between each pair of consecutive stages with a delay of 2 ns. Two pipelined implementation of the processor are contemplated:
(i) a naive pipeline implementation (NP) with 5 stages and
(ii) an efficient pipeline (EP) where the OF stage is divided into stages OF1 and OF2 with execution times of 12 ns and 8 ns respectively.
The speedup (correct to two decimal places) achieved by EP over NP in executing 20 independent instructions with no hazards is _____
[Ans. *] Range: 1.49 to 1.52
For Naive pipelined CPU

$K = 5, T_{seg} = 20 + 2 = 22\ ns, n = 20$
Total time needed for 20 instructions
$= (5 + 20 - 1) \times 22\ ns = 24 \times 22\ ns$
$= 528\ ns$
For Efficient pipelined processor
$T_{seg} = 12 + 2 = 14\ ns;\ k = 6, n = 20$
Total time for 20 instructions
$(6 + 20 - 1) \times 14\ ns = 350\ ns.$
$\text{Speed up} = \frac{t_n}{t_e} = \frac{528}{350} = 1.50857$
$\cong 1.51$

29. A cache memory unit with capacity of N words and block size of B words is to be designed. If it is designed as direct mapped cache, the length of the TAG field is 10 bits. If the cache unit is now designed as a 16-way set-associative cache, the length of the TAG field is _____ bits.
[Ans. *] Range: 14.0 to 14.0
Type of mapping is direct map; for this direct map, 10 bits are required in it's Tag. It is updated to 16 way set Associative map then new tag field size $= 10 + \log_2 16 = 14$ bits, because for k way set associative map design, $\log_2 k$ bits are additionally required to the number of bits in tag field for Direct map design.

30. The value of $\lim_{x \to 1} \frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2}$
(A) is 0
(B) is -1
(C) is 1
(D) Does not exist
[Ans. C]
$\lim_{x \to 1} \left(\frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2} \right)$
$\lim_{x \to 1} \left(\frac{7x^6 - 10x^4}{3x^2 + 6x} \right)$
$= \frac{7 - 10}{3 - 6} = +1$

31. Consider the C function foo and bar given below:

```
int foo (int val)
{
    int x = 0;
    while (val > 0)
    {
        x = x + foo (val − −);
    }
    return val;
}
int bar (int val)
```

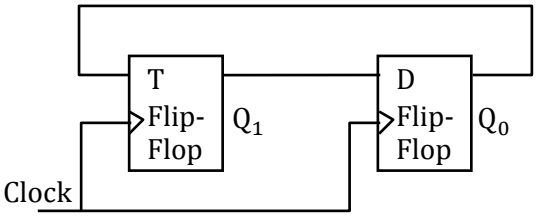
```
{
    int x = 0;
    while (val > 0)
    {
        x = x + bar (val − 1);
    }
    return val;
}
```

Invocations of foo (3) and bar (3) will result in:

(A) Return of 6 and 6 respectively
(B) Infinite loop and abnormal termination respectively
(C) Abnormal termination and infinite loop respectively
(D) Both terminating abnormally

[Ans. C]

32. Consider a combination of T and D flip-flops connected as shown below. The output of the D flip-flop is connected to the input of the T flip-flop and the output of the T flip-flop is connected to the input of the D flip-flop.



Initially, both Q0 and Q1 are set to 1 (before the 1st clock cycle). The outputs

(A) Q_1 Q_0 after the 3rd cycle are 11 and after the 4th cycle are 00 respectively
(B) Q_1 Q_0 after the 3rd cycle are 11 and after the 4th cycle are 01 respectively
(C) Q_1 Q_0after the 3rd cycle are 00 and after the 4th cycle are 11 respectively
(D) Q_1 Q_0after the 3rd cycle are 01 and after the 4th cycle are 01 respectively

[Ans. B]

Input			Output		
T_1	D_0	Clk	Q_1	Q_0	
Initial	Values		1	1	
1	1	↑	0	1	1st clock
1	0	↑	1	0	2nd clock
0	1	↑	1	1	3rd clock
1	1	↑	0	1	4th clock

$T_1 = Q_0$
$D_0 = Q_1$

33. The values of parameters for the Stop-and-Wait ARQ protocol are as given below:
Bit rate of the transmission channel = 1 Mbps.
Propagation delay from sender to receiver = 0.75 ms.
Time to process a frame = 0.25 ms.
Number of bytes in the information frame = 1980

Number of bytes in the acknowledge frame = 20
Number of overhead bytes in the information frame = 20
Assume that there are no transmission errors. Then, the transmission efficiency (expressed in percentage) of the Stop-and-Wait ARQ protocol for the above parameters is _____ (correct to 2decimal places).
[Ans. *] Range: 86.5 to 87.5

34. The number of integers between 1 and 500 (both inclusive) that are divisible by 3 or 5 or 7 is _____.
[Ans. *] Range: 271.0 to 271.0
Number of integers divisible by 3 or 5 or 7
$= n(3 \vee 5 \vee 7) = n(3) + n(5) + n(7) - n(3 \wedge 5) - n(5 \wedge 7) - n(3 \wedge 7) + n(3 \wedge 5 \wedge 7)$
$= \left[\frac{500}{3}\right] + \left[\frac{500}{5}\right] + \left[\frac{500}{7}\right] - \left[\frac{500}{15}\right] - \left[\frac{500}{35}\right] - \left[\frac{500}{21}\right] + \left[\frac{500}{105}\right]$
$= 166 + 100 + 71 - 33 - 14 - 23 + 4$
$= 271$

35. In a database system, unique timestamps are assigned to each transaction using Lamport's logical clock. Let $TS(T_1)$ and $TS(T_2)$ be the timestamps of transactions T_1 and T_2 respectively. Besides, T_1 holds a lock on the resource R, and T_2 has requested a conflicting lock on the same resource R. The following algorithm is used to prevent deadlocks in the database system assuming that a killed transaction is restarted with the same timestamp.
if $TS(T_2) < TS(T_1)$ then
T_1 is killed
else T_2 waits.
Assume any transaction that is not killed terminates eventually. Which of the following is TRUE about the database system that uses the above algorithm to prevent deadlocks?
(A) The database system is both deadlock-free and starvation-free
(B) The database system is deadlock-free, but not starvation-free
(C) The database system is starvation-free, but not deadlock-free
(D) The database system is neither deadlock-free nor starvation-free
[Ans. A]
The algorithm is wound-wait deadlock prevention strategy, hence deadlock free. As the killed transaction restarting with same time stamp, it is starvation free.

36. Consider a database that has the relation schemas EMP(EmpId, EmpName, DeptId), and DEPT(DeptName, DeptId). Note that the DeptId can be permitted to be NULL in the relation EMP. Consider the following queries on the database expressed in tuple relational calculus.
(I) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \forall v \in DEPT\ (t[DeptId] \neq v[DeptId]))\}$
(II) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT\ (t[DeptId] \neq v[DeptId]))\}$
(III) $\{t \mid \exists u \in EMP(t[EmpName] = u[EmpName] \wedge \exists v \in DEPT\ (t[DeptId] \neq v[DeptId]))\}$
Which of the above queries are safe?
(A) (I) and (II) only
(B) (I) and (III) only
(C) (II) and (III) only
(D) (I), (II) and (III)

[Ans. D]

A query in which the output is possibly infinite is said to be unsafe query. A safe expression yields a finite number of tuples as its result.

37. Consider a database that has the relation schema CR(StudentName, CourseName). An instance of the schema CR is as given below.

CR	
Student Name	**Course Name**
SA	CA
SA	CB
SA	CC
SB	CB
SB	CC
SC	CA
SC	CB
SC	CC
SD	CA
SD	CB
SD	CC
SD	CD
SE	CD
SE	CA
SE	CB
SF	CA
SF	CB
SF	CC

The following query is made on the database.

$T_1 \leftarrow \pi_{CourseName}(\sigma_{StudentName='SA'}(CR))$

$T_2 \leftarrow CR \div T1$

The number of rows in T2 is _____.

[Ans. *] Range: 4.0 to 4.0

The output of T_1 is: CourseName

CA
CB
CC

The output of T_2 is: StudentName

SA
SC
SD
SF

38. Let G = (V, E) be any connected undirected edge-weighted graph. The weights of the edges in E are positive and distinct. Consider the following statements:

(I) Minimum Spanning Tree of G is always unique.

(II) Shortest path between any two vertices of G is always unique.

Which of the above statements is/are necessarily true?

(A) (I) only
(B) (II) only
(C) both (I) and (II)
(D) neither (I) nor (II)

[Ans. A]

If the Graph contains distinct weight edges then MST is always unique. But shortest path between any two vertices of G is need not be unique.

39. Let A be n × n real valued square symmetric matrix of rank 2 with

$$\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}^2 = 50$$

Consider the following statements.

(I) One eigenvalue must be in $[-5, 5]$

(II) The eigenvalue with the largest magnitude must be strictly greater than 5

Which of the above statements about engenvalues of A is/are necessarily CORRECT?

(A) Both (I) and (II)
(B) (I) only
(C) (II) only
(D) Neither (I) nor (II)

[Ans. B]

Rank of $A_{n\times n} = 2$

$\Rightarrow n - 2$ Eigen values are zero. Let $\lambda_1, \lambda_2, 0, 0, \ldots, 0$ be the eigen values.

Given that $\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}^2 = 50 \ldots\ldots\ldots (1)$

Wkt $\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}^2 =$ Trace of $(A\,A^T) =$ Trace of A^2 (since A is symmetric)

$= \lambda_1^2 + \lambda_2^2 + 0 + \cdots + 0 \ldots\ldots\ldots (2)$

From (1) and (2)

$\lambda_1^2 + \lambda_2^2 = 50$

$\Rightarrow$ Atleast one Eigen value lies in $[-5, 5]$

$\therefore$ Option (I) is true

Option (II) need not be true, because the Eigen values can be $\lambda_1 = \pm 5, \lambda_2 = \pm 5$

40. Consider the following two functions.

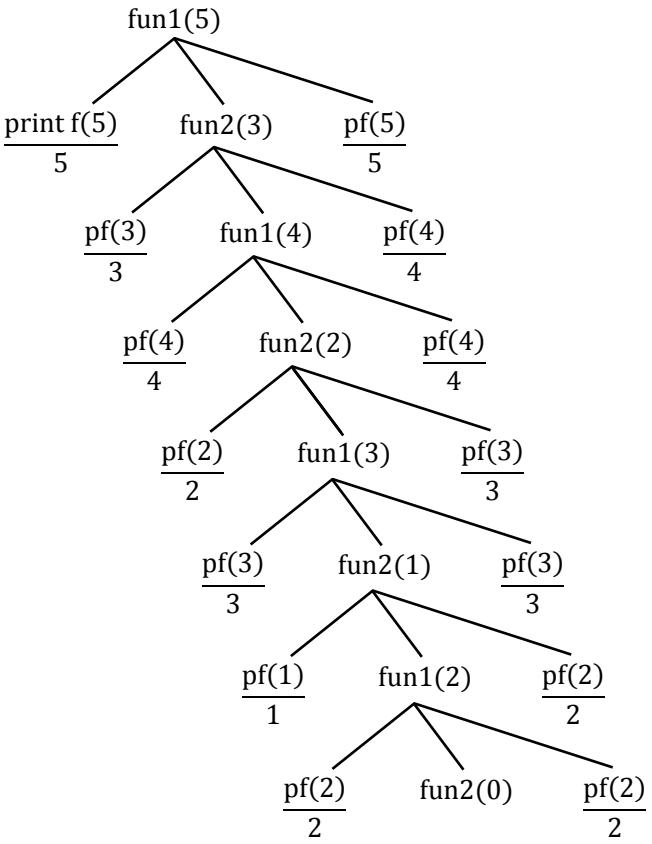
```
void fun1(int n)
{
    if (n == 0) return;
    printf ("%d", n);
    fun2 (n − 2);
    printf("%d", n);
}
```

```
void fun2 (int n)
{
    if (n == 0) return;
    printf ("%d", n);
    fun1 (++n);
    printf("%d", n);
}
```

The output printed when funl (5) is called is

(A) 53423122233445
(B) 53423120112233
(C) 53423122132435
(D) 53423120213243

[Ans. A]



41. Let A and B be finite alphabets and let # be a symbol outside both A and B. Let f be a total function from A* to B*. We say f is computable if there exists a Turing machine M which given an input x in A*, always halts with f(x) on its tape. Let L_f denote the language $\{x\#f(x)|x \in A^*\}$. Which of the following statements is true:
(A) f is computable if and only if L_f is recursive
(B) f is computable if and only if L_f is recursively enumerable
(C) If f is computable then L_f is recursive, but not conversely
(D) If f is computable then L_f is recursively enumerable, but not conversely
[Ans. A]

42. A multithreaded program P executes with x number of threads and uses y number of locks for ensuring mutual exclusion while operating on shared memory locations. All locks in the program are non-reentrant, i.e., if a thread holds a lock l, then it cannot re-acquire lock l without releasing it. If a thread is unable to acquire a lock, it blocks until the lock becomes available. The minimum value of x and the minimum value of y together for which execution of P can result in a deadlock are:
(A) $x = 1, y = 2$
(B) $x = 2, y = 1$
(C) $x = 2, y = 2$
(D) $x = 1, y = 1$
[Ans. D]
Process can get blocked if it tries to acquire the Lock in immediate Succession. However if the underlying platform does not allow the process to activate the acquire lock procedure/system call after Locking earlier, then the correct option would be (C).

43. Recall that Belady's anomaly is that the page-fault rate may increase as the number of allocated frames increases. Now, consider the following statements:
S1: Random page replacement algorithm (where a page chosen at random is replaced) suffers from Belady's anomaly
S2: LRU page replacement algorithm suffers from Belady's anomaly
Which of the following is CORRECT?
(A) S1 is true, S2 is true
(B) S1 is true, S2 is false
(C) S1 is false, S2 is true
(D) S1 is false, S2 is false
[Ans. B]
Belady's anomaly occurs in FIFO page replacement policy. If random page replacement replaces the page same as FIFO then Belady's anomaly may occur.
In LRU policy, it does not occur.

44. Let p, q, and r be propositions and the expression $(p \rightarrow q) \rightarrow r$ be a contradiction. Then, the expression $(r \rightarrow p) \rightarrow q$ is
(A) a tautology
(B) a contradiction
(C) always TRUE when p is FALSE
(D) always TRUE when q is TRUE
[Ans. D]
(A) If $(p \rightarrow q) \rightarrow r$ is false, then $(p \rightarrow q)$ is true and r is false.
The possible cases are
(i) p is true, q is true, r is false
(ii) p is false, q is true, r is false
(iii) p is false, q is false, r is false
For case (iii), $(r \rightarrow p) \rightarrow q$ is false
$\therefore$ It is not a tautology
(B) For case (i) and case (ii), $(r \rightarrow p) \rightarrow q$ is true.
It is not a contradiction
(C) For case (iii), p is false and $(r \rightarrow p) \rightarrow q$ is also false
$\therefore$ option (C) is not true.
(D) Only for case (i) and case (ii), q is true
For both cases, $(r \rightarrow p) \rightarrow q$ is true
$\therefore$ Option (D) is true

45. Consider the following C program.

```
#include <stdio.h>
#include <string.h>
void printlength (char *s, char *t)
{
   unsigned int c = 0;
   int len = ((strlen (s) − strlen (t)) > c)? strlen (s) : strlen (t);
   printf("%d\n", len);
}
void main ()
{
   char * x = "abc";
```

```
    char * y = "defgh";
    printlength (x, y);
}
```

Recall that strlen is defined in string.h as returning a value of type size_t, which is an unsigned int. The output of the program is _____.

[Ans. *] Range: 3.0 to 3.0

Strlen(s) − Strlen(t) will return an unsigned integer which is greater than 'c' so 'len' variable holds value '3'. So output is 3.

46. If G is a grammar with productions

S → SaS | aSb | bSa | SS | ε

Where S is the start variable, then which one of the following strings is not generated by G?

(A) abab
(B) aaab
(C) abbaa
(D) babba

[Ans. D]

(A) S → aSb
→ abSab
→ abab

(B) S → aSb
→ aSaSb
→ aSaSaSb
→ aaab

(C) S → SaS
→ aS
→ abSa
→ abbSaa
→ abbaa

47. The output of executing the following C program is _____.

```
#include <stdio.h>
int total (int v)
{
    static int count = 0;
    while (v)
    {
        count + = v&1;
        v >> = 1;
    }
    return count;
}
void main ()
{
    static int x = 0;
    int i = 5;
    for (; i > 0; i − −)
```

```
    {
        x = x + total (i);
    }
    printf("%d\n", x);
}
```

[Ans. *] Range: 23.0 to 23.0

48. In a RSA cryptosystem, a participant A uses two prime numbers $p = 13$ and $q = 17$ to generate her public and private keys. If the public key of A is 35, then the private key of A is _____.

[Ans. *] Range: 11.0 to 11.0

$p = 13, q = 17$

$K_u = \{e, u\} = \{35\}$

$K_r = d = ?$

RSA steps

1. $p = 13$ $q = 17$
2. $n = 13 \times 17$

$\phi(n) = (p-1)(q-1) = 12 \times 16 = 192$

$d = ?$

$e = 35$

So $(e \times d) \bmod \phi(n) = 1$

$(35 \times d) \bmod 192 = 1$

$d = 11$

49. A computer network uses polynomials over GF(2) for error checking with 8 bits as information bits and uses $x^3 + x + 1$ as the generator polynomial to generate the check bits. In this network, the message 01011011 is transmitted as

(A) 01011011010
(B) 01011011011
(C) 01011011101
(D) 01011011100

[Ans. C]

$$
\begin{array}{r}
01000011 \\
1011\overline{)01011011000} \\
\underline{1011} \\
1100 \\
\underline{1011} \\
1110 \\
\underline{1011} \\
\underbrace{101}_{\text{CRC}}
\end{array}
$$

50. Consider the following languages over the alphabet $\sum = \{a, b, c\}$

Let $L_1 = \{a^n b^n c^m \mid m, n \geq 0\}$ and $L_2 = \{a^m b^n c^n \mid m, n \geq 0\}$

Which of the following are context-free languages?

I. $L_1 \cup L_2$
II. $L_1 \cap L_2$

(A) I only
(B) II only
(C) I and II
(D) Neither I nor II

[Ans. A]

$L_1 = \{a^n\, b^n\, c^m \mid m, n \geq 0\} - CFL$

$L_2 = \{a^m\, b^n\, c^n \mid m, n \geq 0\} - CFL$

Both L_1, L_2 are CFL.

From the closure property union of two CFL is CFL but intersection of two CFL need not be CFL

$\therefore L_1 \cup L_2$ is CFL

$L_1 \cap L_2$ is not CFL

51. Consider the context-free grammar over the alphabet {a, b, c} given below. S and T are nonterminals.

G_1: $S \rightarrow aSb|T, T \rightarrow cT|\varepsilon$

G_2: $S \rightarrow bSa|T, T \rightarrow cT|\varepsilon$

The language $L(G_1) \cap L(G_2)$ is

(A) Finite
(B) Not finite but regular
(C) Context-Free but not regular
(D) Recursive but not context-free

[Ans. B]

G_1: $S \rightarrow aSb|T, T \rightarrow cT|\varepsilon$

$\Rightarrow L(G_1) = \{a^m\, c^n\, b^m \mid m, n \geq, 0\}$

G_2: $S \rightarrow bSa|T, T \rightarrow cT|\varepsilon$

$L(G_2) = \{b^m\, c^n\, a^m \mid m, n \geq 0\}$

Both $L(G_1)$ and $L(G_2)$ are CFL

$L(G1) \cap L(G_2) = c^*$

$\therefore$ regular but not finite

52. Consider the following grammar:

stmt $\rightarrow$ if expr then expr else expr; stmt | o

expr $\rightarrow$ term relop term | term

term $\rightarrow$ id | number

id $\rightarrow$ a | b | c

number $\rightarrow [0 - 9]$

Where relop is a relational operator $(e.g., <, >, \ldots)$, o refers to the empty statement, and if, then, else are terminals.

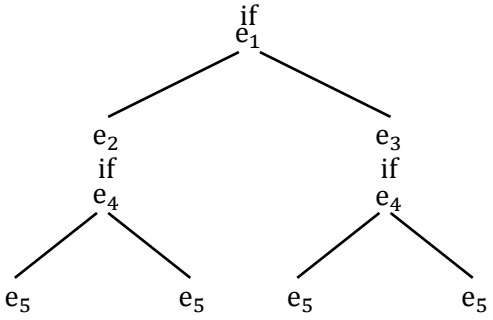
Consider a program P following the above grammar containing ten if terminals. The number of control flow paths in P is _____. For example, the program

if e_1 then e_2 else e_3

has 2 control flow paths, $e_1 \rightarrow e_2$ and $e_1 \rightarrow e_3$.

[Ans. *] Range: 1024.0 to 1024.0

For 2 "if statements", $2^2 = 4$ control flow paths are possible:



So for 10 "If statements", 2^{10} control flow paths will be there.

53. Consider a RISC machine where each instruction is exactly 4 bytes long. Conditional and unconditional branch instructions use PC-relative addressing mode with Offset specified in bytes to the target location of the branch instruction. Further the Offset is always with respect to the address of the next instruction in the program sequence. Consider the following instruction sequence

Instr. No.	Instruction
i:	add R2, R3, R4
i + 1:	sub R5, R6, R7
i + 2:	cmp R1, R9, R10
i + 3:	beq R1, offset

If the target of the branch instruction is i, then the decimal value of the offset is _____.

[Ans. *] Range: -16.1 to -15.9

While executing the i + 3 instruction, the PC content will be the starting address of the i + 4. If the target of the branch instruction is 'i' then processor takes 4 instructions addresses back (Backword jump)

Hence the displacement value is $-4 * 4 = -16$, because each instruction opcode size is 4 bytes.

54. Consider the expression $(a - 1) * ((b + c/3) + d)$. Let X be the minimum number of registers required by an optimal code generation (without any register spill) algorithm for a load/store architecture, in which (i) only load and store instructions can have memory operands and (ii) arithmetic instructions can have only register or immediate operands. The value of X is _____.

[Ans. *] Range: 2.0 to 2.0

Expression is

$(a - 1) \times \big((b + c/3) + d\big)$

load R_1, b $(R_1 \leftarrow b)$

load R_2, c $(R_2 \leftarrow c)$

ADD R_1, R_2 $(R_1 \leftarrow b + c)$

DIV $R_1, \left(3RI \leftarrow \left(\frac{b + c}{3}\right)\right)$

load $R_2, d (R_2 \leftarrow d)$

ADD $R_1, R_2 \left(R_1 \leftarrow \left(\frac{b + c}{3} + d\right)\right)$

load R_2, a($R_2 \leftarrow$ a)
Dec R_2($R_2 \leftarrow$ a − 1)
MUL R_2, R_1 (Final Result is available in R_2)
STORE R_2 on memory
→ only $R_1$and R_2 Registers are sufficient to evaluate the expression

55. Let u and v be two vectors in R^2 whose Euclidean norms satisfy ||u|| = 2||v||. What is the value of α such that w = u + αv bisects the angle between u and v?

(A) 2
(B) ½
(C) 1
(D) $-1/2$

[Ans. A]

If we find two vectors with equal magnitude in the direction of given vectors, then their sum will bisect the angle between them.

∴ In the vector w = u + αv

∴ We have to choose α = 2