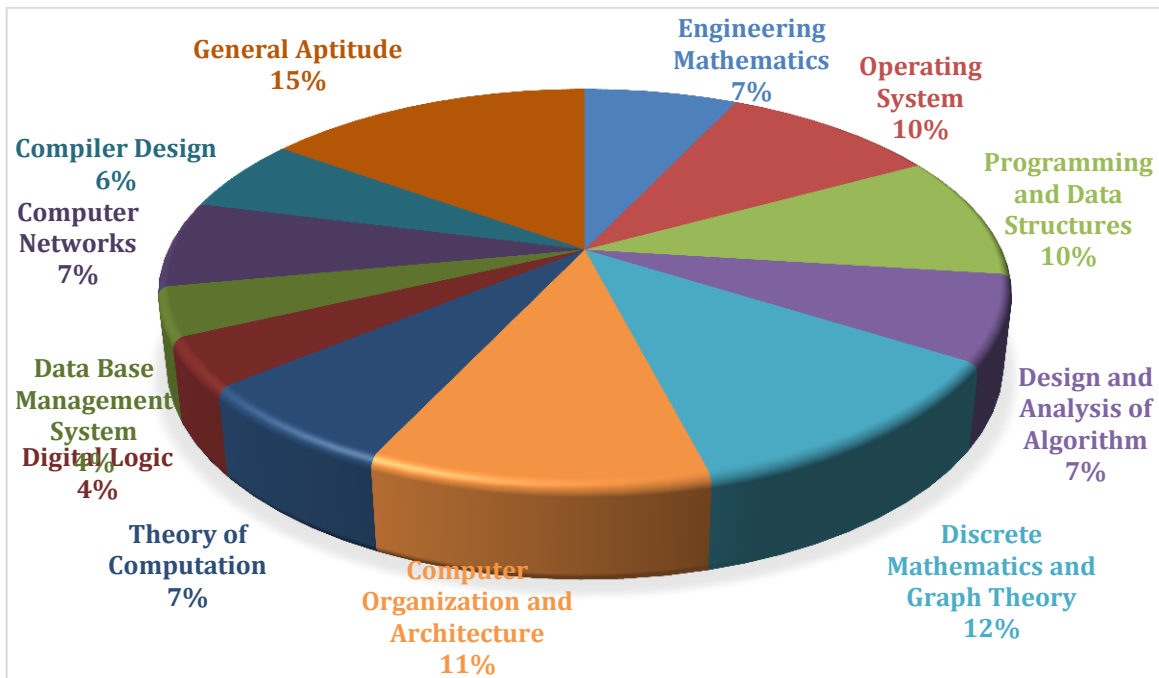


ANALYSIS OF GATE 2018

Computer Science and Information Technology



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CS ANALYSIS-2018_4-Feb_Morning

SUBJECT	No. of Ques.	Topics Asked in Paper(Memory Based)	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 3 2 Marks: 2	Linear Algebra, Eigen Values, Calculus, Probability	Easy	7
Operating System	1 Marks: 4 2 Marks: 3	CPU Scheduling, Demand Paging (Vertical Memory), Dead Lock, Main Memory, Disk Scheduling, Deadlock, IPC	Medium	10
Programming and Data Structures	1 Marks: 4 2 Marks: 3	Queues, C Programming, Programing Code	Medium	10
Design and Analysis of Algorithm	1 Marks: 1 2 Marks: 3	Heaps, Matrix Multiplication	Tough	7
Discrete Mathematics and Graph Theory	1 Marks: 2 2 Marks: 5	First Order Logic, Trees, Graph Theory (Chromatic Number), Set Theory, Spanning Trees	Medium	12
Computer Organization and Architecture	1 Marks: 3 2 Marks: 4	RISC Machine, Cache Memory, Instruction Pipeline, Number Presentation	Easy	11
Theory of Computation	1 Marks: 1 2 Marks: 2	CFL, NFA, Grammar	Medium	7
Digital Logic	1 Marks: 2 2 Marks: 1	K, Maps, Boolean Algebra	Medium	4
Data Base Management System	1 Marks: 0 2 Marks: 2	SQL,	Tough	4
Computer Networks	1 Marks: 3 2 Marks: 2	Protocols (TCP/NPP), Ethernet, TCP Protocol	Medium	7
Compiler Design	1 Marks: 2 2 Marks: 2	Operator Precedeuly, Lexical Analysis	Medium	6
General Aptitude	1 Marks: 5 2 Marks: 5	Functions, Grammar, Numbers, Work, Inference	Easy	15
Total	65			100
Faculty Feedback	Majority of the question were concept based. General Aptitude And Mathematics is Very Easy. Core Subject Questions were 50% easy, 30% medium and 20% tough.			

GATE 2018 Examination*

Computer Science and Information Technology

Test Date: 4-Feb-2018

Test Time: 9:00 AM 12:00 PM

Subject Name: Computer Science and Information Technology

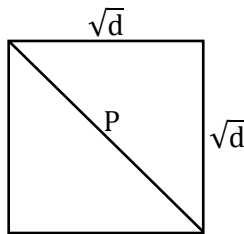
General Aptitude

Q.1 - Q.5 Carry One Mark each.

1. The area of square is 'd'. What is the area of the circle which has the diagonal of the square as its diameter?

- (A) πd (B) πd^2
 (C) $\frac{1}{4}\pi d^2$ (D) $\frac{1}{2}\pi d$

[Ans. D*]



Area of square = d

Side one side of square = \sqrt{d}

Diagonal of square = $\sqrt{d + d} = \sqrt{2d}$

Area of circle = πr^2

$$= \pi \left(\frac{\sqrt{2d}}{2} \right)^2$$

$$= \pi \frac{d}{2}$$

$$= \frac{1}{2} \pi d$$

2. A _____ investigation can sometimes yield new facts, but typically organized once are more successful.

- (A) Meandering (B) Timely
 (C) Consistent (D) Systematic

[Ans. A*]

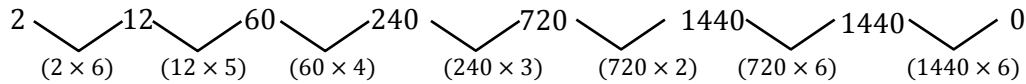
Meandering: wandering aimless/indirect.

3. What is the missing number in the following sequence?

2, 12, 60, 240, 720, 1440, _____, 0

- (A) 2880 (B) 1440
(C) 720 (D) 0

[Ans. B*]



4. What is the smallest natural number which when divided by 20 & by 42 & 76 leaves a remainder '7' is_____?

- (A) 3047 (B) 6047
(C) 7987 (D) 63847

[Ans. C*]

Number is divided by either by 20 or 42 or by 76

$K \times \text{LCM}(20, 42, 76) + \text{Constant difference}$

$= 7890 K + 7$ (K is natural number)

Least number will be $7890+7=7897$.

5. From where are they bringing their book?

_____bringing _____books from _____

- (A) Their, they are, there (B) They are, their, there
(C) There, their, they are (D) They are, there, their

[Ans. B*]

They're used for pointing group.

Their is pointing people.

There is used for place.

Q.6 - Q.10 Carry Two Mark each.

6. In appreciation of social improvement completed in a town, a wealthy philanthropist decided to give gift of Rs.750 to each male senior citizen in the town and Rs. 1000 for female senior citizen. Altogether, were are 300 senior citizens eligible for this gift. However, only $\frac{8}{9}$ th of men and $\frac{2}{3}$ rd of the women claimed the gift. How much money (in Rupees) did the philanthropist give away in total?

- (A) 15000 (B) 200000
(C) 115000 (D) 151000

[Ans. B*]

Male + Female = 300

Total money = $\frac{8}{9}M \times 750 + \frac{2}{3}F \times 1000$

$= \frac{6000}{9}M + \frac{6000}{9}F$

From question (i)

Total money = $\frac{6000}{9}(300) = 2,00,000$

7. A six sided unbiased dice with four green faces and two red faces is rolled seven times. Which of the following combinations is the most likely outcome of the experiment?
- (A) Three green and four red face (B) Four green and three red face
(C) Five green and two red face (D) Six green and one red face

[Ans. C*]

Four green, two red face

$$P(G) = \frac{4}{6} = \frac{2}{3}$$

$$q(R) = \frac{1}{3}$$

$$n = 7$$

$$\begin{aligned} \text{Option (1), } P^7 C_3 \left(\frac{2}{3}\right)^3 \left(\frac{1}{3}\right)^4 \\ = \frac{35 \times 2^3}{(3)^7} = \frac{35 \times 2^3}{(3)^7} \end{aligned}$$

$$\begin{aligned} \text{Option (2), } P(G = 4) = {}^7C_3 \times \left(\frac{2}{3}\right)^4 \times \left(\frac{1}{3}\right)^3 \\ = \frac{35 \times 2^4}{(3)^7} = \frac{35 \times 2^4}{(3)^7} \end{aligned}$$

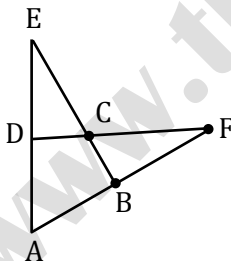
$$\begin{aligned} \text{Option (3), } P(G = 5) = {}^7C_3 \times \left(\frac{2}{3}\right)^5 \times \left(\frac{1}{3}\right)^2 \\ = \frac{21 \times 2^5}{(3)^7} = \frac{42 \times 2^4}{(3)^7} \end{aligned}$$

$$\begin{aligned} \text{Option (4), } P(G = 6) = {}^7C_3 \times \left(\frac{2}{3}\right)^6 \times \left(\frac{1}{3}\right) \\ = \frac{7 \times 2^6}{(3)^7} = \frac{28 \times 2^4}{(3)^7} \end{aligned}$$

Option 3 is maximum value.

So, five green faces and two red faces.

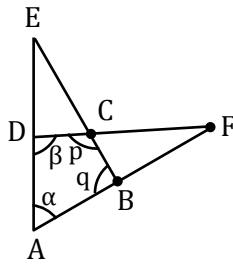
8. In the figure below, $\angle DEC + \angle BFC$ is _____?



- (A) $\angle BCD - \angle BAD$
(C) $\angle BAD + \angle BCD$

- (B) $\angle BAD + \angle BCF$
(D) $\angle CBA + \angle ADC$

[Ans. A*]



$\angle E + \angle F = ?$

$\alpha + q + E = 180 \dots\dots\dots (i)$

$\alpha + \beta + E = 180 \dots\dots\dots (ii)$

$\alpha + \beta + p + q = 360 \dots\dots\dots (iii)$

Equation (i) + (ii) = (iii)

$\alpha + q + E + \alpha + \beta + F = \alpha + \beta + p + q$

$E + F = p - \alpha$

9. In a party 60% invited guests are male and 40% are female. If 80% of invited guests attended party and if all the invited female guests attended the, what would be the ratio of males to females among attendees in the party?

(A) 2:3

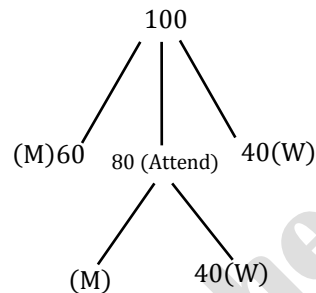
(B) 1:1

(C) 3:2

(D) 2:1

[Ans. B]

Let total number of people of 100



So, M must be $80 - 40 = 40$

Ratio of male to female

40 : 40

1 : 1

10. If $pqr \neq 0, p^{-x} = \frac{1}{q}, q^{-y} = \frac{1}{r}, r^{-z} = \frac{1}{p}$, what is the value of the product $xyz = ?$

(A) -1

(B) $\frac{1}{pqr}$

(C) 1

(D) pqr

[Ans. C*]

$p^{-1} = \frac{1}{q}, q^{-y} = \frac{1}{r}, r^{-z} = \frac{1}{p}$

Put $x = 1, y = 1, z = 1$

$p^{-1} = \frac{1}{q}, q^{-1} = \frac{1}{r}, r^{-1} = \frac{1}{p}$

i.e. $\frac{1}{p} = \frac{1}{q}, \frac{1}{q} = \frac{1}{r}, \frac{1}{r} = \frac{1}{p}$

Which is true i.e.? $\frac{1}{p} = \frac{1}{q} = \frac{1}{r}$

So, $xyz = 1$

Alternative solution:

$$p^x = q$$

$$q^y = r$$

$$r^z = p$$

$$x \log p = \log q$$

$$y \log q = \log r$$

$$z \log r = \log p$$

$$x = \frac{\log q}{\log p}$$

$$y = \frac{\log r}{\log q}$$

$$z = \frac{\log p}{\log r}$$

$$x \times y \times z = 1$$

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Technical

Q.1 - Q.25 Carry One Mark each.

1. The following are some events that occur after a device controller issues an interrupt while process L is under execution.
- P. The processor pushes the process status of L onto the control stack.
 - Q. The processor finishes the execution of the current instruction.
 - R. The processor executes the interrupt service routine.
 - S. The processor pops the process status of L from the control stack.
 - T. The processor loads the new PC value based on the interrupt.

Which one of the following is the correct order in which the events above occur?

- (A) QPTRS
- (B) PTRSQ
- (C) TRPQS
- (D) QTPRS

[Ans. A*]

When device issue an interrupt while a process under execution the following action takes place.

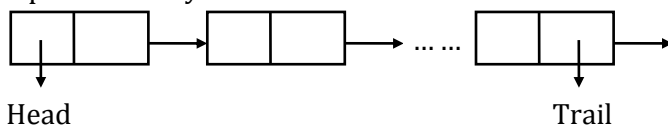
- i. The cpu finishes the execution of the current instruction
 - ii. The cpu pushes the process states into stock
 - iii. The cpu loads the new pc value based on the interrupt
 - iv. The cpu executes the ZSR
 - v. The cpu pops the process states from the stock
2. Let N be an NFA with n states. Let k be the number of states of a minimal DFA which is equivalent to N. Which one of the following is necessarily true?

- (A) $k \geq 2n$
- (B) $k \geq n$
- (C) $k \leq n^2$
- (D) $k \leq 2n$

[Ans. D*]

N is number of states of given NFA (may not be minimal) k is number of states of equivalent min DFA. First we convert NFA to DFA using subset construction algorithm and we get an equivalent DFA which will have atmost 2^n states. Then we can convert this DFA to a minimal DFA and get a minimal DFA with k states where $k \leq 2^n$

3. A queue is implemented using a non-circular singly linked list. The queue has a head pointer and a tail pointer, as shown in the figure. Let n denote the number of nodes in the queue. Let enqueue be implemented by inserting a new node at the head, and dequeue be implemented by deletion of anode from the tail.



Which one of the following is the time complexity of the most time-efficient implementation of enqueue and dequeue, respectively, for this data structure?

- (A) $\theta(1), \theta(1)$
- (B) $\theta(1), \theta(n)$
- (C) $\theta(n), \theta(1)$
- (D) $\theta(n), \theta(n)$

[Ans. B*]

4. The set of all recursive enumerable languages
 (A) Closed under complementation (B) Closed under intersection
 (C) Subset of set is recursive languages (D) An un countable set

[Ans. B]

The set of RE languages is closed under intersection, not closed under complementation, is not a subset of set of REC language and is a countable set.

5. Consider the following two tables and four queries in SQL.
 Book (isbn, bname), stock(isbn, copies)

Query 1: SELECT B.isbn, S.copies
 FROM Book B INNER JOIN Stock S
 ON B.isbn = S.isbn;

Query 2: SELECT B.isbn, S.copies
 FROM Book B LEFT OUTER JOIN Stock S
 ON B.isbn = S.isbn;

Query 3: SLECT Bisbn, S.copies
 FROM Book B RIGHT OUTER JOIN Stock S
 ON B.isbn = S.isbn;

Query 4: SELECT B.isbn, S.copies
 FROM Book B FULL OUTER JOIN Stock S
 ON B.isbn = S.isbn;

Which one of the queries above is certain to have an output that is a superset of the outputs of the

Other three queries?

- (A) Query 1 (B) Query 2
 (C) Query 3 (D) Query 4

[Ans. D*]

Book (isbn, bname)		Stock (isbn, copies)	
2	A	4	100
4	B	6	200
6	C	10	200
8	D	12	400
10	E		

Query 1:

isbn	copies
4	100
6	200
10	200

Query 2:

isbn	copies
4	100
6	200
10	200
2	Null
8	Null

Query 3:

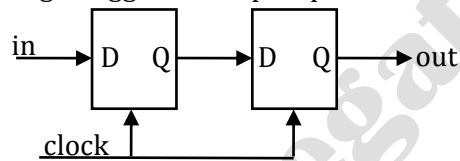
Isbn	copies
4	100
6	200
10	200
12	400

Query 4:

isbn	copies
4	100
6	200
10	200
2	Null
8	Null
12	400

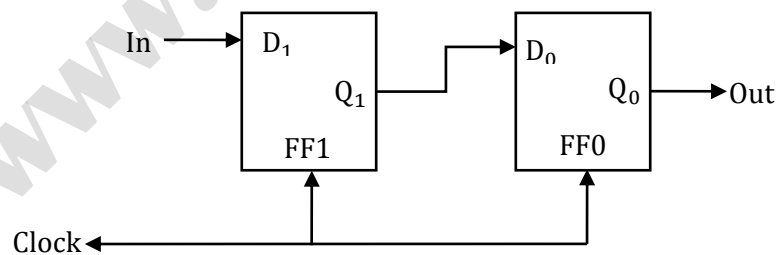
Query 4 is full outer join so that full order joins record set superset of records compare to inner join, left outer join & right outer join.

6. Consider the sequential circuit shown in the figure, where both flip-flops used are positive edge-triggered D flip-flops.



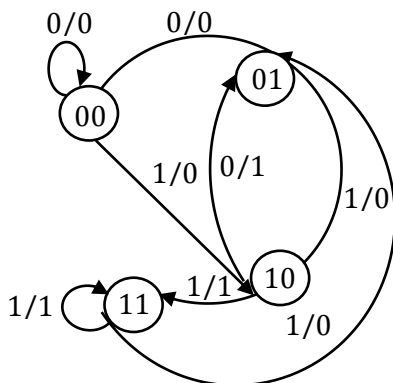
The number of states in the state transition diagram of this circuit that have a transition back to the same state value of "in" is _____

[Ans. *] Range: 2 to 2



P.S.		Input			FF input		N.S.	
Q ₁	Q ₀	x	D ₁ = x	D ₀ = D ₁	Q ₁	Q ₀	Out = Q ₀	
0	0	0	0	0	0	0	0	
0	0	1	1	0	1	0	0	
0	1	0	0	0	0	0	0	
0	1	1	1	0	1	0	0	
1	0	0	0	1	0	1	1	
1	0	1	1	1	1	1	1	
1	1	0	0	1	0	1	1	
1	1	1	1	1	1	1	1	

State Transition Diagram:



The question is on the number of self-loop states.
The numbers of self-loop states are 00 and 11.
Hence answer is 2.

7. Consider a long-lived TCP session with an end-to-end bandwidth of 1 Gbps (= 10^9 bits per second). The session starts with a sequence number of 1234. The minimum time (in seconds, rounded to the closest integer) before this sequence number can be used again is _____.

[Ans. *] Range: 34 to 35

$$1 \text{ sec} = 10^9 \text{ bits}$$

$$2^{32} \times 8$$

$$\frac{2^{32} \times 8}{10^9} = 2^{32} \text{ bytes}$$

$$\Rightarrow 34.35 \text{ sec}$$

8. Which one of the following is closed form expression for the generating function of the sequence $\{a_n\}$, where $a_n = 2n + 3$ for all $n = 0, 1, 2, \dots$?

(A) $\frac{3}{(1-x)^2}$

(B) $\frac{3x}{(1-x)^2}$

(C) $\frac{2-x}{(1-x)^2}$

(D) $\frac{3-x}{(1-x)^2}$

[Ans. D*]

Give, $a_n = 2n + 3$

Since generating function for 1 is $\frac{1}{1-x^2}$ and n is $\frac{x}{(1-x)^2}$, the generating function for a_n is

$$A(x) = \frac{2x}{(1-x)^2} + \frac{3}{1-x}$$

$$= \frac{2x + 3(1-x)}{(1-x)^2} = \frac{3-x}{(1-x)^2}$$

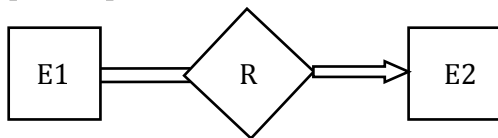
Which is option (D)

9. In an Entity-Relationship (ER) model, suppose R is a many-to-one relationship from entity set E1 to entity set E2. Assume that E1 and E2 participate totally in R and that the cardinality of E1 is greater than the cardinality of E2.

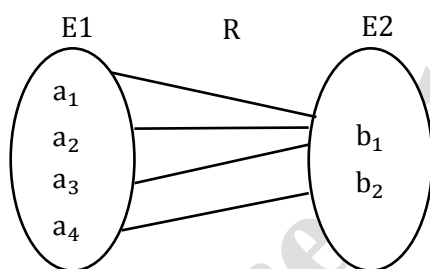
Which one of following is true about R?

- (A) Every entity in E1 is associated with exactly one entity in E2.
- (B) Some entity in E1 is associated with more than one entity in E2.
- (C) Every entity in E2 is associated with exactly one entity in E1.
- (D) Every entity in E2 is associated with at most one entity in E1.

[Ans. A*]



E1 entries > E2 entities



Every entity in E1 is associated with exactly one entity in E2.

10. Consider the following processor design characteristics.

- i. Register-to-register arithmetic operations only
- ii. Fixed-length instruction format
- iii. Hardwired control unit

Which of the characteristics above are used in the design of a RISC processor?

- (A) i and ii only
- (B) ii and iii only
- (C) i and iii only
- (D) i, ii and iii

[Ans. D*]

RISC processor has following characteristics

- I. Register-to-Register arithmetic operation
- II. Fixed-length instruction format
- III. CPI=1 (clock 1Q Instruction)
- IV. Less Addressing modes

V. Hardwired control unit design is used.
Etc.....

11. Which one of the following statements is FALSE?
 (A) Context-free grammar can be used to specify both lexical and syntax rules.
 (B) Type checking is done before parsing.
 (C) High-level language programs can be translated to different Intermediate Representations.
 (D) Arguments to a function can be passed using the program stack.

[Ans. B*]

Type checking is done before parsing is compiler type checking is done after parsing phase.

12. Consider a matrix $A = uv^t$ where $u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$, $v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$. Note that v^T denotes the transpose of v .
The largest eigenvalue of A is _____.

[Ans. 3*]

$$u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}, v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

$$A = uv^T$$

$$= \begin{bmatrix} 1 \\ 2 \end{bmatrix} [1 \quad 1]$$

$$(1 - \lambda)(2 - \lambda) - 2 = 0$$

$$\lambda^2 - 3\lambda = 0$$

$$\lambda(\lambda - 3) = 0$$

$$\lambda = 0$$

$$\text{Or, } \lambda = 3$$

The largest eigen value is 3.

13. Consider the following C program:

```
#include <stdio.h>
int counter = 0;
int calc (int a, int b) {
    int c;
    counter++;
    If (b==3) return (a*a*a);
    else{
        c=calc (a, b/3);
        return (c*c*c);
    }
}
int main() {
    calc(4, 81);
    printf("%d", counter);
}
```

The output of this program is_____.

[Ans. 4*]

14. Consider process executing on an operating system that uses demand paging. The average time for a memory access in the system is M units if the corresponding page is available in memory and D units if the memory access causes a page fault. It has been experimentally measured that the average times taken for a memory access in the process is X units.

Which one of the following is the correct expression for the page fault rate experienced by the process?

- (A) $(D - M)/(X - M)$ (B) $(X - M)/(D - M)$
(C) $(D - X)/(D - M)$ (D) $(X - M)/(D - X)$

[Ans. B*]

MMAT= M

Average main memory access time =X

Page fault rate= P (Assume)

Page fault service time = D

$T_{avg} = (1 - P) \times M + P \times D$

$X = (1 - P)MPD$

$P = \frac{X - M}{D - M}$

15. The value of $\int_0^{\pi/4} x \cos(x^2) dx$ correct to three decimal places (assuming that $\pi = 3.14$) is_____

[Ans. *]Range: 0.27 to 0.30

$$\int_0^{\pi/4} x \cos(x^2) dx$$

Let, $t = x^2$

$dt = 2x dx$

$\Rightarrow sdx = \frac{dx}{2}$

When $x = 0, t = 0$ and when $x = \frac{\pi}{4}, t = \left(\frac{\pi}{4}\right)^2$

So required integral reduce to

$$\int_0^{\left(\frac{\pi}{4}\right)^2} \cos dt = \sin t \Big|_0^{\left(\frac{\pi}{4}\right)^2}$$

$$= \sin \left(\frac{\pi}{4}\right)^2 - \sin(0)$$

$$= \sin \left(\frac{\pi}{4}\right)^2 = 0.28898$$

≈ 0.289 (Rounded to 3 decimal places)

16. Match the following:

Field	Length in bits
P: UDP header part number	I. 48
Q: Ethernet MAC address	II. 8
R: IPV6 next header	III. 32
S: TCP header's sequence number	IV. 16

Codes:

- | | |
|-----------------------------|----------------------------|
| (A) P: II, Q:I, R:IV, S:III | (B) P:IV, Q:I, R:II, S:III |
| (C) P:II, Q:I, S:III, R:IV | (D) P:I, Q:II, R:III, S:IV |

[Ans. C*]

UDP Header's Port Number \Rightarrow 16 bit
 Ethernet MAC Address \Rightarrow 48 bit
 IPv6 Next Header \Rightarrow 8 bit
 TCP Header's Sequence Number \Rightarrow 32 bit

17. Let \oplus and \odot denote the Exclusive Or and Exclusive NOR operations, respectively. Which one of the following is NOT CORRECT?

- | | |
|---|---|
| (A) $\overline{P \oplus Q} = P \odot Q$ | (B) $\overline{P} \oplus Q = P \odot Q$ |
| (C) $\overline{P} \oplus \overline{Q} = P \oplus Q$ | (D) $(P \oplus \overline{P}) \oplus Q = (P \oplus \overline{P}) \odot \overline{Q}$ |

[Ans. D*]

- (A) $\overline{P \oplus Q} = P \odot Q$ True
 (B) $\overline{P} \oplus Q = P \odot Q$ True
 (C) $\overline{P} \oplus \overline{Q} = P \oplus Q$ True
 (D) $(P \oplus \overline{P}) \oplus Q = (P \oplus \overline{P}) \odot \overline{Q}$ False
 $(P \oplus \overline{P}) \oplus Q = 1 \oplus Q = \overline{Q}$
 $(P \oplus \overline{P}) \odot \overline{Q} = 0 \oplus \overline{Q} = Q$
 $\therefore (P \oplus \overline{P}) \oplus Q \neq (P \oplus \overline{P}) \odot \overline{Q}$

18. Consider the following statements the slow start phase of the TCP congestion control algorithm. Note that cwnd stands for the TCP congestion window and MSS denotes the Maximum Segment Size.

- (i) The cwnd increases by 2 MSS on every successful acknowledgment.
- (ii) The cwnd approximately doubles on every successful acknowledgement.
- (iii) The cwnd increases by 1 MSS every round trip time.
- (iv) The cwnd approximately doubles every round trip time.

Which one of the following is correct?

- | | |
|----------------------------------|---------------------------------|
| (A) Only (ii) and (iii) are true | (B) Only (i) and (iii) are true |
| (C) Only (iv) is true | (D) Only (i) (iv) are true |

[Ans. C*]

Cwnd approximately doubles every round trip time.

19. The post-order traversal of a binary tree is 8, 9, 6, 7, 4, 5, 2, 3, 1. The in order traversal of the same tree is 8, 6, 9, 4, 7, 2, 5, 1, 3. The height of a tree is the length of the longest path from the root to any leaf. The height of the binary tree above is_____.

[Ans. *] Range:4 to 4*

20. Let G be a finite group on 84 elements. The size of a largest possible proper subgroup of G is_____.

[Ans. *] Range: 42 to 42*

Given $|G| = 84$

By Lagrang's theorem any subgroup size is a divisor of 84

But a proper subgroup cannot have same size as group.

So largest divisor of 84, other than 84 is 42.

So, largest proper subgroup can have in size of 42.

21. Consider a system with 3 processes that share 4 instances of the same resource type. Each process can request a maximum of K instances. Resource instances can be requested and released only one at a time. The largest value of K that will always avoid deadlock is _____.

[Ans. *] Range: 2 to 2*

Process Id	Max	R=4 Allocation	(shared) Available
P ₁	k = 2	1	(1)
P ₂	k = 2	1	2
P ₃	k = 2	1	3
			4

3 + 1 ← Extra

For $k = 2 \Rightarrow P_1, P_2, P_3 >$ safe sequence.

Hence: Maximum K='2' instances.

(OR)

No. of process = 3

Number of instances of same resource = 4

∴ Demand < no. of processes + no. of resources

$3k < 3 + 4$

$K < \frac{7}{3} \Rightarrow K < 2.33 \Rightarrow K = 2$

22. A 32-bit wide main memory unit with a capacity of 1 GB is built using 256M × 4 - bit RAM chips. The number of rows of memory cells in the DRAM chip is 2¹⁴. The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closest integer) of the time available for performing the memory read/write operations in the main memory unit is _____.

[Ans. *] Range 59 to 60*

No. of rows of memory cells = 2¹⁴

The time taken to perform one refresh operation is 50 ns.

Time taken to perform refresh all the rows

= 2¹⁴ × 50 × 10⁻⁹sec = 0.8192 msec

$$\begin{aligned} \text{Overhead of the refreshing operation} &= \frac{0.8192 \text{ msec}}{2 \text{ ms}} \times 100\% \\ &= 40.96\% \end{aligned}$$

The % of the time available for performing the memory read/write Operations = $1 - 40.96\% = 59.04\%$

23. Consider the following C program.

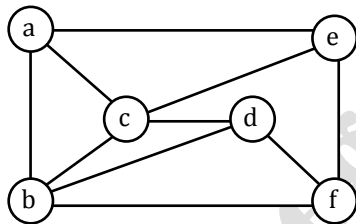
```
#include<stdio.h>
struct ournode {
    char x, y, z;
};
int main() {
    struct ournode p = {'1', '0', 'a' + 2};
    struct ournode *q = &p;
    printf("%c, %c", *((char*)q+1), *((char*)q+2));
    return 0;
}
```

The output of this program is:

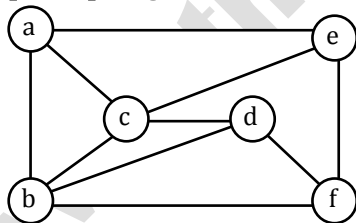
- (A) 0, c (B) 0, a + 2
(C) '0', 'a + 2' (D) '0', 'c'

[Ans. A*]

24. The chromatic number of the following graph is _____.

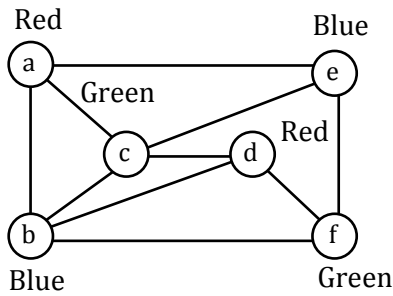


[Ans. *]Range: 3 to 3



Since the largest complete sub graph is K_3 , chromatic number is atleast 3.

We can try for a chromatic number of 3 by using 3 colors, as follow:



Since we have successfully, properly coloured all vertices with only 3 colors, the chromatic number of this graph is 3.

25. Two people, P and Q, decide to independently roll two identical dice, each with 6 faces, numbered 1 to 6. The person with the lower number wins. In case of a tie, they roll the dice repeatedly until there is no tie. Define a trial as a throw of the dice by P and Q. Assume that all 6 numbers on each dice are equi-probable and that all trials are independent. The probability (rounded to 3 decimal places) that one of them wins on the third trial is_____.

[Ans. *] Range: 0.021 to 0.024

P (one of them wins in 3rd trial)

$$= P(1^{\text{st}} \text{ trial is Tie}) \times P(2^{\text{nd}} \text{ trial is Tie}) \times P(\text{one of them wins 3rd trial})$$

$$P(\text{Tie in any trial}) = P(P = 1 \text{ and } Q = 1) + P(P = 2 \text{ and } Q = 2) + \dots + P(P = 6 \text{ and } Q = 6)$$

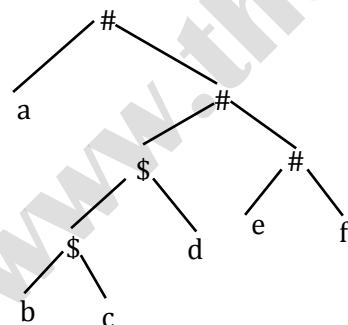
$$= \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36}$$

$$= \frac{6}{36} = \frac{1}{6}$$

$$\text{so required probability} = \frac{1}{6} \times \frac{1}{6} \times \frac{5}{6} = \frac{5}{216} = 0.23 \text{ (rounded to 3 decimal palces)}$$

Q.26 - Q.55 Carry Two Mark each.

26. Consider the following parse tree for the expression a # b \$ c \$ d # e # f, involving two binary operators \$ and #.



Which one of the following is correct for the given parse tree?

- (A) \$ has higher precedence and is left associative; # is right associative
- (B) # has higher precedence and is left associative; \$ is right associative
- (C) \$ has higher precedence and is left associative; # is left associative
- (D) # has higher precedence and is right associative; \$ is left associative

[Ans. A*]

If any given parse tree or syntax free low level operators having higher precedence than upper level operators.

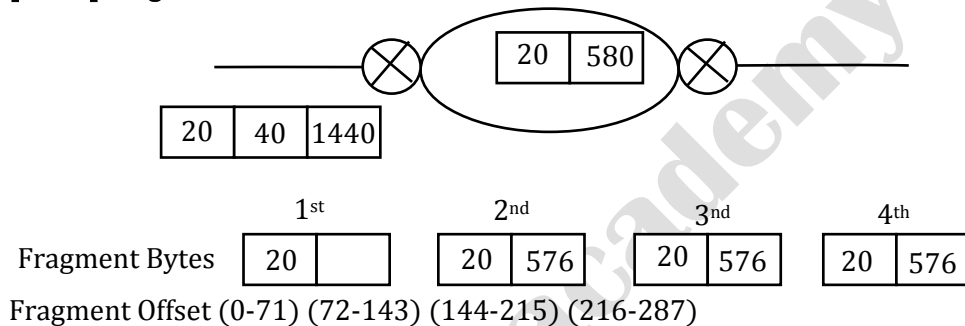
Hence here \$ is higher precedence than #. \$ is left associative because in the sub expression b \$ c \$ d. b \$ c will be evaluated first as per given tree.

As per the given tree structure right # is higher precedence than left #. Hence it is right associative.

27. Consider an IP packet with a length of 4,500 bytes that includes a 20-byte IPv4 header and a 40-byte TCP header. The packet is forwarded to an IPv4 router that supports a Maximum Transmission Unit (MTU) of 600 bytes. Assume that the length of the IP header in all the outgoing fragments of this packet is 20 bytes. Assume that the fragmentation offset value stored in the first fragment is 0.

The fragmentation offset value stored in the third fragment is _____

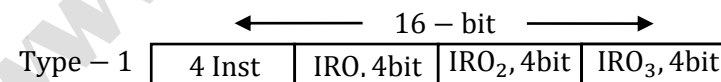
[Ans. *]Range: 144 to 144



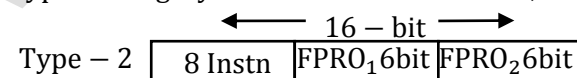
28. A processor has 16 integer registers (R0, R1, ..., R15) and 64 floating point registers (F0, F1..., F63). It uses a 2-byte instruction format. There are four categories of instruction. Type-1, Type-2, Type-3 Type-4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand (1R + 1F). Type-4 category consists of N instructions, each with a floating point register operand (1F). The maximum value of N is _____.

[Ans. *] Range: 32 to 32*

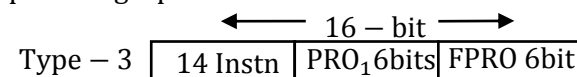
Type-1 category consist of '4' instructions, land with '3' integer operands (3 Rs.)

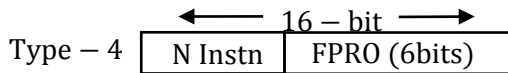


Type-2 category consist of '8' instructions, each with 2 floating point Register operands.



Type-3 category consist of 14 instructions, each with one Integer register of one floating point Reg. operands





Total number of instruction possible 2^{10} , but it support all types

$$\therefore N = 2^{10} - (4 \times 2^6) - (8 \times 2^6) - (14 \times 2^4) = 32$$

29. Consider the weights and values of items listed below. Note that there is only one unit of each item.

Item number	Weight (in Kgs)	Value (in Rupees)
1	10	60
2	7	28
3	4	20
4	2	24

The task is to pick a subset of these items such that their total weight is no more than 11 Kgs and their total value is maximized. Moreover, no item may be split. The total value of items picked by an optimal algorithm is denoted by V_{opt} . A greedy algorithm sorts the items by their value-to-weight ratios in descending order and packs them greedily, starting from the first item in the ordered list. The total value of items picked by the greedy algorithm is denoted by V_{greedy} . The value of $V_{opt} - V_{greedy}$ is _____.

[Ans. *]Range:16 to 16

30. Consider matrix P has Eigen vectors are multiple of $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$

Consider the following statements

- I. P does not have an inverse
- II. P has a repeated Eigen value
- III. P cannot be diagonalised

Which of the following is true?

- (A) Only I and III are necessarily true
- (B) Only II is necessarily true
- (C) Only I and II are necessarily true
- (D) Only II and III are necessarily true

[Ans. D*]

Only Eigen vector is $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$ multiples means that eigen value is repeated since if eigen

Values were distinct we will get one more independent eigen vector. So, II P has repeated

eigen values is true. I need not be true since $\begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$ has repeated eigen values and

yet it is invertible. III is true since if a 2×2 matrix has only one linearly independent eigen vector, surely it cannot be diagonalized.

31. Assume that multiplying a matrix G_1 of dimension $p \times q$ with another matrix G_2 of dimension $q \times r$ requires pqr scalar multiplications. Computing the product of n matrices $G_1 G_2 G_3 \dots G_n$ can be done by parenthesizing in different ways. Define $G_i G_{i+1}$ as an explicitly computed pair for a given parenthesization if they are directly multiplied. For

example, in the matrix multiplication chain $G_1G_2G_3G_4G_5G_6$ using parenthesization $(G_1(G_2G_3))(G_4(G_5G_6))$, G_2G_3 and G_5G_6 are the only explicitly computed pairs.

Consider a matrix multiplication chain $F_1F_2F_3F_4F_5$, where matrices F_1, F_2, F_3, F_4 and F_5 are of dimensions $2 \times 25, 25 \times 3, 3 \times 16, 16 \times 1$ and 1×1000 , respectively. In the parenthesization of $F_1F_2F_3F_4F_5$ that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

- (A) $F_1 F_2$ and $F_3 F_4$ only (B) $F_2 F_3$ only
(C) $F_3 F_4$ only (D) $F_1 F_2$ and $F_4 F_5$ only

[Ans. C*]

32. Let N be the set of natural numbers. Consider the following sets.

P: Set of Rational numbers (positive and negative)

Q: Set of functions from $\{0, 1\}$ to N

R: Set of functions from N to $\{0, 1\}$

S: Set of finite subsets of N .

Which of the sets above are countable?

- (A) Q and S only (B) P and S only
(C) P and R only (D) P, Q and S only

[Ans. D*]

P : Set of rational number \rightarrow countable

Q : Set of functions from $\{0, 1\}$ to $N \rightarrow N$

0	1

$N \times N$

0 can be assigned in N ways

1 can be assigned in N ways

There are $N \times N$ functions, cross product of countable set in countable.

R : Set of functions from N to $\{0, 1\}$

1	2	3	4	5	6				

Each of these boxes can be assigned to 0 or 1 so each such function is a binary number with infinite number of bits.

Example: 0000..... is the binary number corresponding to 0 is assigned to all boxes and so on.

Since each such binary number represents a subset of N (the set of natural numbers) by characteristic function method, therefore, the set of such function is same as power set of N which is uncountable due to Cantor's theorem, which says that power set of a countable infinite set is always uncountable infinite. S: Set of finite subsets of N countable infinite since we are counting only finite subsets.

So P, Q and S are countable.

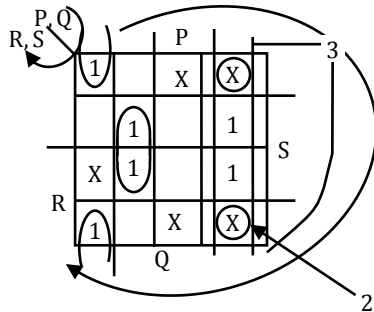
33. Consider the min-term list form of a Boolean function F given below.

$$F(P, Q, R, S) = \sum m(0, 2, 5, 7, 9, 11) + d(3, 8, 10, 12, 14)$$

Here, m denotes a minterm and d denotes a don't care term. The number of essential prime implicants of the function F is _____

[Ans. *]Range: 3 to 3

$$F(P, Q, R, S) = \sum m(0, 2, 5, 7, 9, 11) + d(3, 8, 10, 12, 14)$$



Number of EPI = 3

34. Consider a simple communication system where multiple nodes are connected by a shared broadcast medium (like Ethernet or wireless). The nodes in the system use the following carrier-sense based medium access protocol. A node that receives a packet to transmit will carrier-sense the medium for 5 units of time. If the node does not detect any other transmission in this duration, it starts transmitting its packet in the next time unit. If the node detects another transmission, it waits until this other transmission finishes, and then begins to carrier-sense for 5 time units again. Once they start to transmit, nodes do not perform any collision detection and continue transmission even if a collision occurs. All transmissions last for 20 units of time. Assume that the transmission signal travels at the speed of 10 meters per unit time in the medium.

Assume that the system has two nodes P and Q, located at a distance d meters from each other. P starts transmitting a packet at time $t = 0$ after successfully completing its carrier-sense phase. Node Q has a packet to transmit at time $t = 0$ and begins to carrier-sense the medium.

The maximum distance d (in meters, rounded to the closest integer) that allows Q to successfully avoid a collision between its proposed transmission and P's ongoing transmission is _____.

[Ans. *]Range: 50 to 50

35. The number of possible min-heaps containing each value from $\{1, 2, 3, 4, 5, 6, 7\}$ exactly once is _____.

[Ans. *]Range: 80 to 80

36. The size of the physical address space of a processor is 2^P bytes. The word length is 2^W bytes. The capacity of cache memory is 2^N bytes. The size of each cache block is 2^M words. For a K-way set-associative cache memory, the length (in number of bits) of the tag fields is

(A) $P - N - \log_2 K$

(B) $P - N + \log_2 K$

(C) $P - N - M - W - \log_2 K$

(D) $P - N - M - W + \log_2 K$

[Ans. B*]

$$PAS = 2^P \text{ Bytes, Word length} = 2^W \text{ Bytes}$$

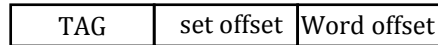
Cache memory = 2^N Bytes

K-way set Associative cache.

$$\text{No. of cache blocks (N)} = \frac{2^N \text{ Bytes}}{2^M \times 2^W \text{ Bytes}} = \frac{2^{N-(M+W)}}{2}$$

$$\text{No. of sets in cache (S)} = \frac{2}{K}$$

$$\text{No. of bits needed for set offset} = \log_2 \left(\frac{2^{N-(M+W)}}{K} \right)$$



$$(N - (M + W)) - \log_2 k \quad (M + W)$$

$$\text{TAG (bits)} = P - [(N - (M + W)) - \log_2 k + (M + W)]$$

$$= P - N + M + W + \log_2 k - M - W$$

$$\text{TAG} = P - N + \log_2 k$$

37. Consider the following C code. Assume that unsigned long int type length is 64 bits.
unsigned long int fun(unsigned long int n)

```
{
    unsigned long int i, j = 0, sum = 0;
    for (i = n; i > 1; i = i/2) j++;
    for (; j > 1; j = j/2) sum++;
    return(sum);
}
```

The value returned when we call fun with the input 2^{40} is _____.

- (A) 4 (B) 5
(C) 6 (D) 40

[Ans. B*]

38. Consider the following languages:

- I. $\{a^m b^n c^p d^q \mid m + p = n + q, \text{ where } m, n, p, q \geq 0\}$
 II. $\{a^m b^n c^p d^q \mid m = n, p = q, \text{ where } m, n, p, q \geq 0\}$
 III. $\{a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q, \text{ where } m, n, p, q \geq 0\}$
 IV. $\{a^m b^n c^p d^q \mid mn = p + q, \text{ where } m, n, p, q \geq 0\}$

Which of the languages above are context-free?

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

[Ans. B*]

- I. $\{a^m b^n c^p d^q \mid m + p = n + q\}$ is clearly CFL since, we can rearrange the equation as $m - n + p - q = 0$ which can be done by push, pop, push and pop and check if stack is empty at end.
 II. $\{a^m b^n c^p \mid m = n \text{ and } p = q\}$ is clearly CFL since, one comparison at a time can be done by pda.
 III. $\{a^m b^n c^p d^q \mid m = n = p \text{ and } p \neq q\}$ is not CFL since $m = n = p$ is a double comparison which cannot be done by PDA.

IV. $\{a^m b^n c^p d^q \mid mn = p + q\}$ is not a CFL, since mn involves multiplying number of a's and number b's which cannot be done by a PDA.

So, only I and II are CFL's.

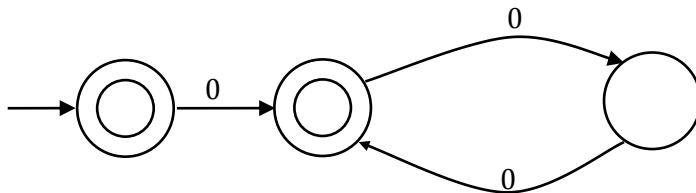
39. Given a language L , define L^i as follows:

$$L^0 = \{\epsilon\}$$

$$L^i = L^{i-1} \cdot L \text{ for all } i > 0$$

The order of a language L is defined as the smallest k such that $L^k = L^{k+1}$.

Consider the language L_1 (Over alphabet 0) accepted by the following automaton.

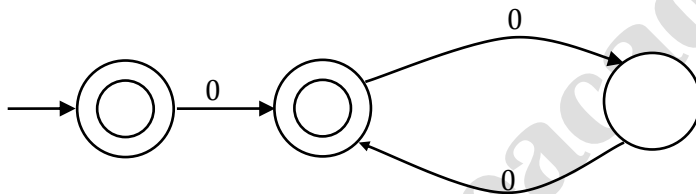


The order of L_1 is _____.

[Ans. *]Range:2 to2

We need to find smallest value of k which satisfies

$$L_1^k = L_1^{k+1}$$



$$L_1 = \epsilon + (00)^*$$

$$\text{Try } k = 0: L_1^0 = L_1^1$$

$$\Rightarrow \epsilon = L_1 \text{ which is false.}$$

So order not 0.

$$\text{Try } k = 1: L_1^1 = L_1^2$$

$$\Rightarrow L_1^2 = L_1$$

$$\text{Now, } L_1^2 = (\epsilon + 0(00)^*)(\epsilon + 0(00)^*)$$

$$= \epsilon + 0(00)^*(\epsilon + 0(00)^*) = 0^*$$

$$\text{Clearly } L_1^2 \neq L_1$$

So order is not 1.

$$\text{Try } k = 2: L_1^2 = L_1^3$$

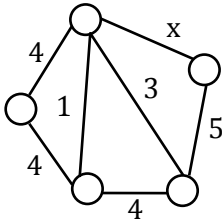
$$\text{Now, } L_1^2 = L_1^2 \cdot L_1$$

$$= 0^*(\epsilon + 0(00)^*)$$

$$\text{Clearly } L_1^3 = L_1^2 = 0^*$$

(So order of L_1 is 2

40. Consider the following undirected graph G:



Choose a value for x that will maximize the number of minimum weight spanning trees (MWSTs) of G . The number of MWSTs of G for this value of x is _____

[Ans. *]Range:4 to 4

41. Consider the relations $r(A,B)$ and $s(B,C)$ where $s.B$ is a primary key and $r.B$ is a foreign key referencing $s.B$. Consider the query

$Q: r \bowtie (\sigma_{B < 5}(S))$

Let LOJ denote the natural left outer-join operation. Assume that r and s contain no null values.

Which one of the following queries is NOT equivalent to Q ?

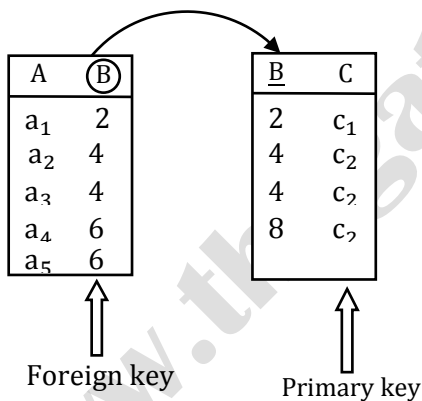
(A) $\sigma_{B < 5}(r \bowtie s)$

(B) $\sigma_{B < 5}(rLOJ s)$

(C) $r LOJ(\sigma_{B < 5}(s))$

(D) $\sigma_{B < 5}(r)LOJ s$

[Ans. C*]



Given query: $r \bowtie (\sigma_{B < 5}(s))$

A	B	C
a ₁	2	C ₁
a ₂	4	C ₁
a ₃	4	C ₁

A: $\sigma_{B < 5}(r \bowtie s)$

A	B	C
a ₁	2	C ₁
a ₂	4	C ₁
a ₃	4	C ₁

B: $\sigma_{B < 5}(r \bowtie s)$

A	B	C
a ₁	2	C ₁
a ₂	4	C ₁
a ₃	4	C ₁

C: $r \bowtie (\sigma_{B < 5}(s))$

A	B	C
a ₁	2	c ₁
a ₂	4	c ₁
a ₃	4	c ₁
a ₄	6	Null
a ₅	6	Null

D: $\sigma_{B < 5}(r) \bowtie s$

A	B	C
a ₁	2	C ₁
a ₂	4	C ₁
a ₃	4	C ₁

Option "C" query result not equal to given query.

42. Consider the following program written in pseudo-code.

Assume that x and y are integers.

```
count (x, y)
{
  if (y != 1) {
    if (x != 1) {
      print ( "*" );
      count (x/2, y);
    }

    else {
      y = y - 1;
      count (1024, y);
    }
  }
}
```

The number of times that the print statement is executed by the call count (1024, 1024) is _____

[Ans. *] Range:10230 to 10230

43. Consider a storage disk with 4 platters (numbered as 0,1, 2 and 3), 200 cylinders (numbered as 0, 1,....., 199), and 256 sectors per track (numbered as 0, 1, ..., 255). The following 6 disk requests of the form [sector number, cylinder number, platter number] are received by the disk controller at the same time:

[120, 72, 2], [180, 134, 1], [60, 20, 0] [212, 86, 3], [56, 116, 2], [118, 16, 1]

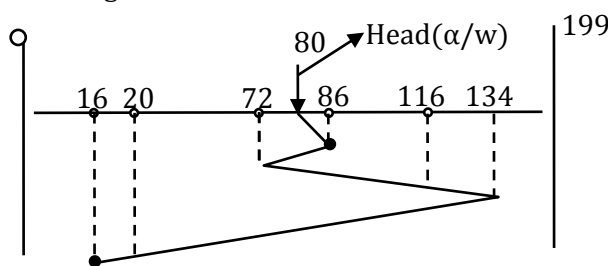
Currently the head is positioned at sector number 100 of cylinder 80, and is moving towards higher cylinder numbers. The average power dissipation in moving the head over 100 cylinders is 20 milliwatts and for reversing the direction of the head movement once is 15 milliwatts. Power dissipation associated with rotational latency and switching of head between different platters is negligible.

The total power consumption in milliwatts to satisfy all of the above disk requests using the Shortest Seek Time First disk scheduling algorithms is_____.

[Ans. *]Range: 85 to 85

Cylinder request 72, 134, 20, 86, 116, 16

SSTF Algorithm



Average power consumption for 100 cylinders = 20 MW & reversing 15 MW.

No of cylinder movements

$$= |80 - 86| + |86 - 72| + |72 - 134| + |134 - 16|$$

$$= 6 + 14 + 62 + 118 = 200.$$

Total power dissipation $40 + 45 = 85$

44. Consider the unsigned 8-bit fixed point binary number representation below.

$b_7 b_6 b_5 b_4 . b_3 b_2 b_1 b_0$

where the position of the binary point is between b_3 and b_2 . Assume b_7 is the most significant bit. Some of the decimal numbers listed below cannot be represented exactly in the above representation:

- (i) 31.500
- (ii) 0.875
- (iii) 12.100
- (iv) 3.001

Which one of the following statements is true?

- (A) None of (i), (ii), (iii), (iv) can be exactly represented
- (B) Only (ii) cannot be exactly represented
- (C) Only (iii) and (iv) cannot be exactly represented
- (D) Only (i) and (ii) cannot be exactly represented

[Ans. C*]

Given Binary number

$b_7 b_6 b_5 b_4 . b_3 b_2 b_1 b_0$

- (i) $31.500 = (11111.100)_2$

It can be representable

- (ii) $0.875 \times 2 = 1.75 \Rightarrow 1$

- .75 \times 2 = 1.50 \Rightarrow 1
 0.50 \times 2 = 1.00 \Rightarrow 1
 (.111)₂ representable
 (iii) 12.100
 (01100.)₂ for fraction
 .100 \times 2 = .200 \Rightarrow 0
 .200 \times 2 = 0.400 \Rightarrow 0
 0.400 \times 2 = 0.800 \Rightarrow 0
 0.800 \times 2 = 1.600 \Rightarrow 1
 0.600 \times 2 = 1.200 \Rightarrow 1
 0.200 \times 2 = 0.400 \Rightarrow 0
 (01100.000110 ...)₂

For representing this at least 5 fraction bits needed
 Hence not representable.

- (iv) 3.001
 (00011.)₂
 .001 \times 2 = 0.002 \Rightarrow 0
 .002 \times 2 = 0.004 \Rightarrow 0
 .004 \times 2 = 0.008 \Rightarrow 0
 .008 \times 2 = 0.016 \Rightarrow 0
 .0016 \times 2 = 0.0032 \Rightarrow 0

Fraction part is needed more than '3' bits
 Hence it cannot represent exacting in the given form.

\therefore iii & iv are cannot be representable.
 Option (C)

45. Consider the following problem. L (G) denotes the language generated by a grammar G.
 L (M) denotes the language accepted by a machine M.
 I. For an unrestricted grammar G and a string W, whether $w \in L(G)$
 II. Given a Turing machine M, Whether L (M) is regular
 III. Given two grammars G1 and G2, whether $L (G1) = L (G2)$
 IV. Given an NFA N, whether there is a deterministic PDA P such that N and P accept the same language.

Which one of the following statements is correct?

- (A) Only I and II are un-decidable (B) Only III is un-decidable
 (C) Only II and IV are un-decidable (D) Only I, II and III are un-decidable

[Ans. D]

- I. Membership problem for RE \rightarrow undecidable
 II. II. Regularity problem for RE \rightarrow undecidable
 III. III. Equivalence problem for RE \rightarrow undecidable
 IV. Since DPDA P exists for every nfa N and equivalent to it, this problem is trivially decidable.

46. Let G be a graph with $100!$ Vertices, with each vertex labeled by a distinct permutation of the numbers $1, 2, \dots, 100$. There is an edge between vertices u and v if and only if the label of u can be obtained by swapping two adjacent numbers in the label of v . Let y denote the degree of a vertex in G , and z denote the number of connected components in G .

Then, $y + 10z =$ _____

[Ans. *]Range: 109 to 109

The graph has $100!$ Vertices which each vertex labelled by one of the $100!$ Permutation.

Let us find degree of each vertex.

Let us take a vertex whose labeling is say $1, 2, 3, 4, \dots, 100$. Now it will be connected to all vertices where exactly 2 of the adjacent numbers all swapped.

The two swapped numbers could be $(1, 2), (2, 3), (3, 4)$ etc. upto $(99, 100)$ which makes for 99 edges for each such vertex.

So the graph is a regular graph with each vertex connected to 99 other vertices.

So $y = 99$

The number of connected components $= z = 1$ since we can go from any vertex to any other vertex by only swapping 2 adjacent number at a time, many times i.e. there is a path from any vertex to any other vertex. Graph is connected.

So $z = 1$

So $y + 10z = 99 + 10 \times 1 = 109$

47. The instruction pipeline of a RISC processor has the following stages. Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Perform Operation (PO) and Write back (WB). The IF, ID, OF and WB stages take 1 clock cycle each for every instruction. Consider a sequence of 100 instructions. In the PO stage, 40 instructions take 3 clock cycles each, 35 instructions take 2 clock cycles each, and the remaining 25 instructions take 1 clock cycle each. Assume that there are no data hazards and no control hazards. The number of clock cycles required for completion of execution of the sequence of instructions is _____

[Ans. 219*]Range:219 to 219

5-stage RISC pipeline.

(IF, ID, OF, PO, WB)

All the stages takes 1 clock cycle for 100 sequence instructions except 'PO' stage.

PO takes 3 clocks \rightarrow 40 instructions

2 clocks \rightarrow 35 instructions

1 clocks \rightarrow 25 Instructions

First instruction takes '7' clocks

	1	2	3	4	5	6	7
I_1	IF	ID	OF	←PO	→		WB

No. of clocks required for completion of execution of the sequence instructions

$$= 7 + 39 \times 3 + 35 \times 2 + 25 \times 1$$

$$= 219$$

48. In a system, there are three types of resources: E, F and G. Four processes P_0, P_1, P_2 and P_3 execute concurrently. At the outset, the processes have declared their maximum resource requirements using a matrix named Max as given below. For example, $\text{Max}[P_2, F]$ is the

maximum number of instances of F that P_2 would require. The number of instances of the resources allocated to the various processes at any given state is given by a matrix named Allocation.

Consider a state of the system with the Allocation matrix as shown below, and in which 3 instances of E and 3 instances of F are the only resources available.

Allocation			
	E	F	G
P_0	1	0	1
P_1	1	1	2
P_2	1	0	3
P_3	2	0	0

Max			
	E	F	G
P_0	4	3	1
P_1	2	1	4
P_2	1	3	3
P_3	5	4	1

From the perspective of deadlock avoidance, which one of the following is true?

- (A) The system is in safe state
- (B) The system is not in safe state, but would be safe if one more instance of E were available
- (C) The system is not in safe state, but would be safe if one more instance of F were available
- (D) The system is not in safe state, but would be safe if one more instance of G were available

[Ans. A*]

Process Id	Max Demand	Allocation	Need	Available
	E F G	E F G	E F G	<3 3 0>
P_0	4 3 1	1 0 1	3 3 0	<4 3 1>
P_1	2 1 4	1 1 2	1 0 2	<5 3 4>
P_2	1 3 3	1 0 3	0 3 0	<6 4 6>
P_3	5 4 1	2 0 0	3 4 1	<8 4 6>

Safe sequence $\langle P_0 - P_2 - P_1 - P_3 \rangle$

\therefore option (A)

49. Consider the first-order logic sentence

$$\phi \equiv \exists s \exists t \exists u \forall v \forall w \forall x \forall y \Psi(s, t, u, v, w, x, y)$$

Where $\Psi(s, t, u, v, w, x, y)$ is a quantifier-free first-order logic formula using only predicate symbols, and possibly equality, but no function symbols. Suppose ϕ has a model with a universe containing 7 elements.

Which one of the following statements is necessarily true?

- (A) There exists at least one model of ϕ with universe of size less than or equal to 3.
- (B) There exists no model of ϕ with universe of size less than or equal to 3.
- (C) There exists no model of ϕ with universe of size greater than 7.

(D) Every model of φ has a universe of size equal to 7.

[Ans. A*]

50. A lexical analyzer uses the following patterns to recognize three tokens T_1 , T_2 , and T_3 over the alphabet $\{a, b, c\}$.

$T_1: a?(b|c) * a$

$T_2: b?(a|c) * b$

$T_3: c?(b|a) * c$

Note that 'x?' means 0 or 1 occurrence of the symbol x. Note also that the analyzer outputs the token that matches the longest possible prefix.

If the string bbaacabc is processed by the analyzer, which one of the following is the sequence of tokens it outputs?

(A) $T_1T_2T_3$

(B) $T_1T_1T_3$

(C) $T_2T_1T_3$

(D) T_3

[Ans. D*]

Ans is T_3T_3 because from first T_3 bbaac is taken from second T_3 abc is taken, longest possible prefix.

Hence T_3T_3 token output.

51. Consider the following four relational schemas. For each schema, all non-trivial functional dependencies are listed. The underlined attributes are the respective primary keys.

Schema I: Registration (rollno, courses)

Field 'courses' is a set-valued attribute containing the set of courses a student has

Registered for.

Non-trivial functional dependency:

rollno \rightarrow courses

Schema II: Registration (rollno, courseid, email)

Non-trivial functional dependencies:

rollno, courseid \rightarrow email

email \rightarrow rollno

Schema III: Registration (rollno, courseid, marks, grade)

Non-trivial functional dependencies:

rollno, courseid \rightarrow marks, grade

Marks \rightarrow grade

Schema IV: Registration (rollno, courseid, credit)

Non-trivial functional dependencies:

rollno, courseid \rightarrow credit

Courseid \rightarrow credit

Which one of the relational schemas above is in 3NF but not in BCNF?

(A) Schema I

(B) Schema II

(C) Schema III

(D) Schema IV

[Ans. B*]

Schema II: Registration (rollno, courseid, email)

Primary key [rollno, coursed]
 Non-trivial functional dependencies:
 { rollno, courseid → email
 email → rollno }
 candidate keys {rollno, coursed},
 email coursed}
 Given relation is in 3NF but not in BCNE.

52. Let G be a simple undirected graph; Let T_D be a depth first search tree of G . Let T_B be a breath first search tree of G . Consider the following statements.
- No edge of G is a cross edges with respect to T_D (Across edge in G is between two nodes neither of which is an ancestor of two other in T_D)
 - For every edge (u, v) of G , if u is at depth i and v is depth j in T_B $|i - j| = 1$
- Which of the statements above must necessarily be TRUE?
- (A) I (B) II
 (C) I and II (D) Neither of them
- [Ans. A*]**

53. Consider Guwahati (G) and Delhi (D) whose temperatures can be classified as high (H), medium (M) and low (L). Let $P(H_G)$ denote the probability that Guwahati has high temperature. Similarly, $P(M_G)$ and $P(L_G)$ denotes the probability of Guwahati having medium and low temperatures respectively. Similarly, we use $P(H_D)$, $P(M_D)$ and $P(L_D)$ for Delhi.

The following table gives the conditional probabilities for Delhi's temperature given Guwahati's temperature.

	H_D	M_D	L_D
H_G	0.40	0.48	0.12
M_G	0.10	0.65	0.25
L_G	0.01	0.50	0.49

Consider the first row in the table above. The first entry denotes that if Guwahati has high temperature (H_G) then the probability of Delhi also having a high temperature (H_D) is 0.40; i.e., $P(H_D|H_G) = 0.40$. Similarly, the next entries are $P(M_D |H_G) = 0.48$ and $P(L_D |H_G) = 0.12$. Similarly for the other rows.

If it is known that $P(H_G) = 0.2$, $P(M_G) = 0.5$ and $P(L_G) = 0.3$, then the probability (correct to two decimal places) that Guwahati has high temperature given that Delhi has high temperature is ____.

[Ans. *] Range: 0.60 to 0.62

The condition probability table given is

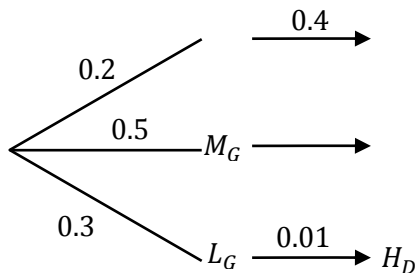
	H_D	M_D	L_D
H_G	0.40	0.48	0.12
M_G	0.10	0.65	0.25
L_G	0.01	0.50	0.49

$p(H_G) = 0.2$

$P(M_G) = 0.5$

$P(L_G) = 0.3$

Drawing the tree diagram for HD we get,



$$P(H_G|H_D) = \frac{P(H_G \cap H_D)}{P(H_D)}$$

From diagram, $P(H_G \cap H_D) = 0.2 \times 0.4$

$$P(H_G|H_D) = \frac{0.2 \times 0.4}{0.133} = 0.60 \text{ (Rounding unto 2 decimal place)}$$

54. Consider the following C program:

```
# include <stdio.h>
void fun1 (char *s1, char *s2)
{
    char *tmp;
    tmp = s1;
    s1 = s2;
    s2 = tmp;
}
void fun 2 (char **s1, char **s2)
{
    char *tmp;
    tmp = *s1;
    *s1 = *s2;
    * s2 =tmp;
}
int main() {
    char *str1 = "Hi", *str2 = "Bye";
    fun1 (str1, str2); printf("%s %s", str1, str2);
    fun2 (&str1, &str2); printf("%s %s", str1, str2);
    return 0;
}
```

The output of the program above is

- (A) Hi Bye Bye Hi (B) Hi Bye Hi Bye
(C) Bye Hi Hi Bye (D) Bye Hi Bye Hi

[Ans. A*]

55. Consider the following solution to the producer-consumer synchronization problem. The shared buffer size is N. Three semaphores empty, full and mutex are defined with respective initial values of 0, N and 1. Semaphore empty denotes the number of available slots in the buffer, for the consumer to read from. Semaphore full denotes the number of

available slots in the buffer, for the producer to write to. The placeholder variables, denotes by P, Q, R, and S, in the code below can be assigned either empty or full. The valid semaphore operations are: wait () and signal ().

Producer:	Consumer:
<pre>do{ wait (P); wait (mutex); //Add item to buffer signal (mutex); signal (Q); }while (1);</pre>	<pre>do{ wait (R); wait (mutex); //Consume item from buffer signal (mutex); signal (S); }while(1);</pre>

Which one of the following assignments to P, Q, R and S will yield the correct solution?

- (A) P: full, Q: full, R: empty, S: empty (B) P: empty, Q: empty, R: full, S: full
 (C) P: full, Q: empty, R: empty, S: full (D) P: empty, Q: full, R: full, S: empty

[Ans. C*]

Semaphore variable are

Empty= ϕ {No. of empty slots in buffer}

Full= N {No. of full slots in buffer}

Mutex= 1 {Mutual exclusion b/w producer & consumer}

Producer

```
Do {
  Wait <full>;
  Wait <Mutex>;
  "Add item to
  Buffer ,,
  Signal <mutex>;
  Signal<empty>;
}while (1);
```

Consumer

```
Do {
  Wait <empty>;
  Wait <Mutex>;
  "Consume item from
  buffer,,
  Signal<Mutex>;
  Signal<full>;
} while (1);
```