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GATE 2017

Computer Science & Information Technology

Questions with Detailed Solutions

FORENOON SESSION

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01. 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

01. Ans: (D)

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

02. 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

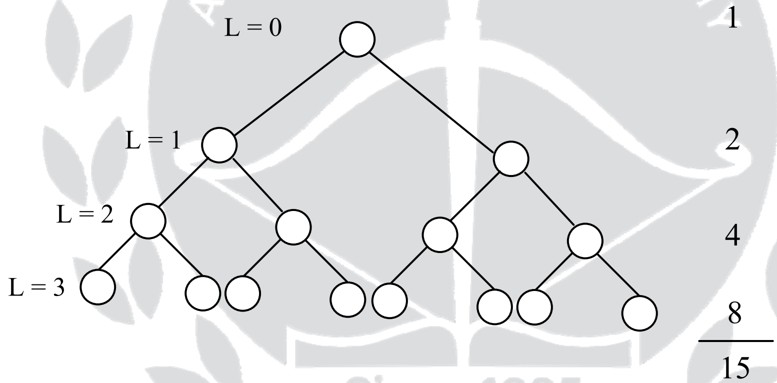
(B) 3 and 14 respectively

(C) 4 and 14 respectively

(D) 3 and 15 respectively

02. Ans: (B)

Sol:



Minimum = 3   Maximum = 14

03. 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^{-f} to 2^{f}

(B) 2^{-f} to $(2^{f} - 2^{-f})$

(C) 0 to 2^{f}

(D) 0 to $(2^{f} - 2^{-f})$

03. Ans: (D)

Sol: 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 to $2^i - 1$)

Range of the Decimal values for only fraction part is (0 to $(1-2^{-f})$)

Range of the Real number is 0 to $(2^i - 1 + 1 - 2^{-f})$

$= 0$ to $(2^i - 2^{-f})$

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

$V \rightarrow W$

$VW \rightarrow X$

$Y \rightarrow VX$

$Y \rightarrow Z$

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

(A) $V \rightarrow W$, $V \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow Z$

(B) $V \rightarrow W$, $W \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow Z$

(C) $V \rightarrow W$, $V \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow X$, $Y \rightarrow Z$

(D) $V \rightarrow W$, $W \rightarrow X$, $Y \rightarrow V$, $Y \rightarrow X$, $Y \rightarrow Z$

04. Ans: (A)

Sol: As $V \rightarrow W$, delete W from $VW \rightarrow X$ results in $V \rightarrow X$

As $V \rightarrow X$, delete X from $Y \rightarrow VX$ results in $Y \rightarrow V$

The irreducible set is

$V \rightarrow W$

$V \rightarrow X$

$Y \rightarrow V$

$Y \rightarrow Z$

05. 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.

05. Ans: 3

Sol: 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 = $\frac{12}{4} = 3$

06. 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

06. Ans: (D)

Sol: $(\sim p \Rightarrow \sim q)$

$\Leftrightarrow (q \Rightarrow p)$ (By contrapositive equivalence)

$\Leftrightarrow (\sim q \vee p)$ $(\because (a \rightarrow b) \equiv (\sim a \vee b))$

07. 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.

07. Ans: (D)

Sol: 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.

08. 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

08. Ans: (A)

09. 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 $\mathbf{R}^{11}$.

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

09. Ans: (C)

Sol: 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)

$= k\ (k< n)$

$\therefore$ The system has infinitely many solutions

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

10. Ans: (B)

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

11. Consider the following context-free grammar over the alphabet $\Sigma = \{a, b, c\}$ with S as the start symbol:

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

Which one of the following represents the language generated by the above grammar?

(A) $\{(ab)^n (cb)^n \mid n \geq 1\}$

(B) $\{(ab)^n cb^{m_1} cb^{m_2} \ldots cb^{m_n} \mid n, m_1, m_2, \ldots, m_n \geq 1\}$

(C) $\{(ab)^n (cb^m)^n \mid m, n \geq 1\}$

(D) $\{(ab)^n (cb^n)^m \mid m, n \geq 1\}$

11. Ans: (C)

Sol: $S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

$S \rightarrow abScT \qquad T \rightarrow bT \mid b$

$S \rightarrow abcT \qquad T \rightarrow b^+$

$$\Rightarrow \left.\begin{matrix} S \rightarrow abScT \\ S \rightarrow abc\,b^+ \end{matrix}\right\} b^+ = b^m \mid m \geq 1$$

$\Rightarrow S \rightarrow abScb^+$

$S \rightarrow abcb^+$

$\Rightarrow S \rightarrow (ab)\, S\, (cb^+) \mid ab.\, cb^+$

$\therefore L = \{(ab)^n (cb^+)^n \mid n \geq 1\}$

$L = \{(ab)^n (cb^m)^n \mid m, n \geq 1\}$

12. 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)
$p_1 = a - b$
$q_1 = p * c$
$p_2 = u * v$
$q_2 = p + q$

12. Ans: (B)

Sol: All assignments in SSA are to variables with distinct names

$p_3 = a - b$

$q_4 = P_3 * c$

$p_4 = u * v$

$q_5 = P_4 + q_4$

13. 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) $(A_7.B_7.\overline{S}_7 + \overline{A}_7.\overline{B}_7.S_7)$ is 1

(D) $(A_0.B_0.\overline{S}_0 + \overline{A}_0.\overline{B}_0.S_0)$ is 1

13. Ans: (C)

Sol: $A_7\ A_6\ A_5\ A_4\ A_3\ A_2\ A_1 A_0$

$B_7\ B_6\ B_5\ B_4\ B_3\ B_2\ B_1\ B_0$

$\underline{\ \ C_6\ C_5\ C_4\ C_3\ C_2\ C_1\ C_0\ \ }$

$\underline{C_7\ S_7\ S_6\ S_5\ S_4\ S_3\ S_2\ S_1\ S_0}\rightarrow$ Result

Overflow occurs, when S_7 is '0' while adding 2 number of negative data or S_7 is '1' while adding 2 number of positive data.

Expression is $A_7\ B_7\ \overline{S}_7 + \overline{A}_7\ \overline{B}_7\ S_7$

14. 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

14. Ans: (A)

Sol: A birthday attack is a type of cryptographic attack that exploits the mathematics behind the birthday problem in probability theory. This attack can be used to abuse communication between two or more parties. The attack depends on the higher likelihood of collisions found between random attack attempts and a fixed degree of permutations.

1: Sender can launch the attack

Suppose Alice wants to trick Bob into signing a fraudulent contract. Mallory prepares a fair contract m and a fraudulent one m'. She then finds a number of positions where m can be changed without changing the meaning, such as inserting commas, empty lines, one versus two spaces after a sentence, replacing synonyms, etc. By combining these changes, she can create a huge number of variations on m which are all fair contracts.

2. The third party attacker can also launch the attack

The birthday attack on digital signatures allows a third party to replace one digitally signed message with a different one without altering the signature.

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

15. Ans: 18

Sol: If T has n vertices, then number of edges in T is n–1

By sum of degrees of vertices theorem

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

$$= 2\,(9) = 18$$

16. 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

16. Ans: (D)

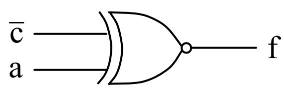
17. Consider the Karnaugh map given below, where X represents "don't care" and blank represents 0.

dc \ ba	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 _______.

17. Ans: 1

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



Hence, only one NOR gate is sufficient.

18. 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 ________.

18. Ans: 0

Sol: 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.

$\therefore$ The median of Y = 0

19. Consider the following table:

Algorithms	**Design Paradigms**
(P) Kruskal	(i) Divide and Conquer
(Q) Quicksort	(ii) Greedy
(R) Floyd-Warshall	(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)

19. Ans: (C)

20. 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________.

20. Ans: 0.05

Sol: 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

$$\therefore \text{Missrate of } L_2 \text{ cache} = \frac{\text{misses in } L_2 \text{ cache}}{\text{miss rate in } L_1 \text{ cache}} = \frac{0.005}{0.1} = 0.05$$

21. 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.

21. Ans: (A)

Sol: While loop will be terminated after reaching last node of list 'n' and last node next pointer pointing to the first node of list m.

22. Consider the following grammar:

$P \rightarrow xQRS$

$Q \rightarrow yz \mid z$

$R \rightarrow w \mid \varepsilon$

$S \rightarrow y$

What is FOLLOW(Q)?

(A) {R} (B) {w}

(C) {w, y} (D) {w, \$}

22. Ans: (C)

Sol: FOLLOW (Q) = First (R) – {ε} ∪ First (S)

= {w, ε} – {ε} ∪ {y} = {w, y}

23. Consider the first-order logic sentence F:∀x(∃yR(x, y)). Assuming non-empty logical domain, which of the sentences below are implied by F?

I. ∃y(∃xR(x, y))

II. ∃y(∀xR(x,y))

III. ∀y(∃xR(x,y))

IV. ¬∃x(∀y¬R(x,y))

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

23. Ans: (B)

Sol: We have $\forall_x (\exists_y R(x,y)) \Rightarrow \exists_y (\exists_x R(x,y))$

And $\forall_x (\exists_y R(x,y)) \Leftrightarrow \sim \exists_x (\forall_x \sim R(x,y))$

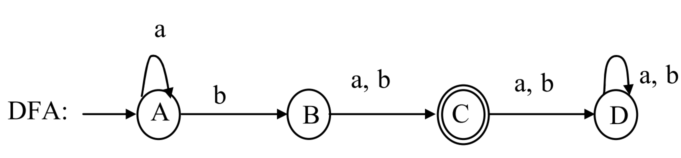
∴ The formulas I and IV are implied by F.

24. 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_______.

24. Ans: 4

Sol: $r = (a+b)^* b (a+b)$

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



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

25. 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__________.

25. Ans: 2.6

Sol: 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

26. 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_______.

26. Ans: –16

Sol: 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.

27. 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

27. Ans: (B)

Sol: 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.

28. 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________.

28. Ans: 11

Sol: $p = 13, q = 17$

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

$K_r = d = ?$

RSA steps

1. $p = 13 \quad q = 17$

2. $n = 13 \times 17$

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

$d = ?$

$e = 35$

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

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

$d = 11$

29. The number of integers between 1 and 500 (both inclusive) that are divisible by 3 or 5 or 7 is ______.

29. Ans: 271

Sol: Number of integers divisible by 3 or 5 or 7

$= n(3 \vee 5 \vee 7) = n(3) + n(5) + n(7) - n(3 \wedge 5) - n(5 \wedge 7) - n(3 \wedge 7) + n(3 \wedge 5 \wedge 7)$

$= \left\lfloor \frac{500}{3} \right\rfloor + \left\lfloor \frac{500}{5} \right\rfloor + \left\lfloor \frac{500}{7} \right\rfloor - \left\lfloor \frac{500}{15} \right\rfloor - \left\lfloor \frac{500}{35} \right\rfloor - \left\lfloor \frac{500}{21} \right\rfloor + \left\lfloor \frac{500}{105} \right\rfloor$

$= 166 + 100 + 71 - 33 - 14 - 23 + 4$

$= 271$

30. 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 2 decimal places).

30. Ans: 89.33

Sol: B = 1 Mbps

$T_p = 0.75$ ms

$T_{proc} = 0.25$ ms

Payload = 1980 B

Ack = 20 B

OH = 20 B

L = Payload + OH = 1980 + 20 = 2000 Bytes

$T_x = \frac{L}{B} = \frac{2000 \times 8}{1 \times 10^6} = 16$ ms

$$T_{ax} = \frac{20 \times 8}{1 \times 10^6}$$

$= 160\ \mu sec$

$= 0.16$ msec

Total time $= T_x + T_p + T_{proc} + T_{ax} + T_p + T_{aproc}$

= 16 ms + 0.75 ms + 0.25 ms+ 0.16 ms + 0.75 ms

= 17.91 ms

$$\eta = \frac{T_x}{\text{Total Time}}$$

$$= \frac{16}{17.91} = 89.33\%$$

31. If G is a grammar with productions

$S \rightarrow SaS \mid aSb \mid bSa \mid SS \mid \varepsilon$

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

31. Ans: (D)

(A) $S \rightarrow aSb \rightarrow abSab \rightarrow abab$

(B) $S \rightarrow aSb \rightarrow aSaSb \rightarrow aSaSaSb \rightarrow aaab$

(C) $S \rightarrow SaS \rightarrow aS \rightarrow abSa \rightarrow abbSaa \rightarrow abbaa$

32. 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________.

32. Ans: 5

Sol: Since $n = 31 = 2^5 - 1$

By using optimal searching algorithm it takes in worst case '5' comparison.

33. 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 _________.

33. Ans: 3

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

34. 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)

34. Ans: (A)

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

35. 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

35. Ans: (C)

Sol:

```
1011)  01011011000 (01000011
        1011
       ----------
            1100
            1011
       ----------
             1110
             1011
       ----------
              101
              \_/
              CRC
```

36. 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 _______.

36. Ans: 2

Sol: Expression is

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

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, $\left(3R1 \leftarrow \left(\frac{b+c}{3}\right)\right)$

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.

37. Consider the following grammar:

stmt → if expr then expr else expr; stmt | o

expr → term relop term | term

term → id | number

id → a | b | c

number → [0-9]

where relop is a relational operator (e.g., <,>, …), 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 $e_1 \rightarrow e_3$.

37. Ans: 20

Sol: As program containing 10 if terminals, all those can be determined with the productions stmt → if expr then expr else expr, stmt and each of this production contain 2 control flow paths and the program contain total of 20 control paths.

38. 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)

38. Ans: (B)

Sol: 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 $\sum_{i=1}^{n}\sum_{j=1}^{n} A_{ij}^2 = 50$ --------(1)

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

$= \lambda_1^2 + \lambda_2^2 + 0 + \ldots + 0$ --------(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 $\lambda_1 = \pm 5$, $\lambda_2 = \pm 5$

39. 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 exit

39. Ans: (C)

Sol: $\underset{x\to 1}{\text{Lt}} \left(\frac{x^7 - 2x^5 + 1}{x^3 - 3x^2 + 2} \right)$

$\underset{x\to 1}{\text{Lt}} \left(\frac{7x^6 - 10x^4}{3x^2 - 6x} \right)$

$= \frac{7 - 10}{3 - 6} = +1$

40. 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.

40. Ans: 14

Sol: 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.

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

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

41. Ans: (B)

Sol: G_1: $S \rightarrow aSb \mid T,\ T \rightarrow cT \mid \varepsilon$

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

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

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

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

$L(G_1) \cap L(G_2) = c^*$

$\therefore$ regular but not finite

42. 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);
}
```

42. Ans: 23

43. 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 $w = u + \alpha v$ bisects the angle between u and v?

(A) 2 (B) ½

(C) 1 (D) –1/2

43. Ans: (A)

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

$\therefore$ In the vector $w = u + \alpha\, v$

$\therefore$ We have to choose $\alpha = 2$

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44. Consider the following two functions.

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

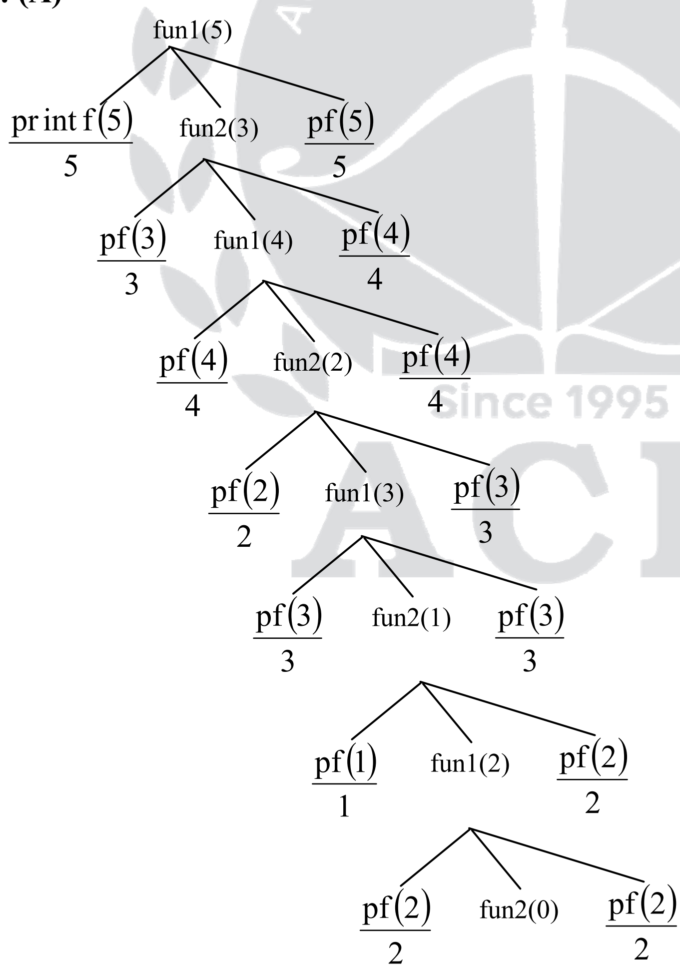
```
void fun2 (int n)
{
        if (n = = 0) return;
        printf (“%d”, n);
        fun1 (++n);
        printf(“%d”, n);
}
```

The output printed when funl (5) is called is

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

44. Ans: (A)

Sol:



45. 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

45. Ans: (A)

46. 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

46. Ans: (D)

Sol: Both functions are terminated abnormally.

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

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

47. Ans: (A)

Sol: $L_1 = \{a^n b^n c^m \mid m, n \geq 0\}$ – 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.

48. 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_____.

48. Ans: 78

Sol: Associativity = 2, Number of cache blocks = 256

Number of sets in cache memory = 128 (S_0 to S_{127})

Mapping expression is K Mod 128

Block Request order is

0, 128, 256, 128, 0, 128, 256, 128, 1, 129, 257, 129, 1, 129, 257, 129.

Only 2 sets are accessed, known as S_0 and S_1

Set 0	1st time Reference CFM H CFM H CFM H ~~0~~, 128, **~~256~~**, 128, ~~0~~, 128, **~~256~~**, 128 No. of CFMS = 3	2nd time Reference CFM H CFM H CFM H CFM H ~~0~~, 128, **~~256~~**, 128, ~~0~~, 128, 256, 128 No. of CFMS = 4
Set 1	1st time Reference CFM H CFM H CFM H ~~1~~, 129, **~~257~~**, 129, ~~1~~, 129, **~~257~~**, 129 No. of CFMS = 3	2nd time Reference CFM CFM H CFM H CFM H ~~1~~, 129, **~~257~~**, 129, ~~1~~, 129, 257, 129 No. of CFMS = 4

CFM = conflict miss, H = Hit

Total no. of conflict misses first time = 6

2nd time onwards = 8 each time

If it is Repeated '10' times, total no. of conflict misses occurred = $6 + 8 \times 9 = 78$

49. 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

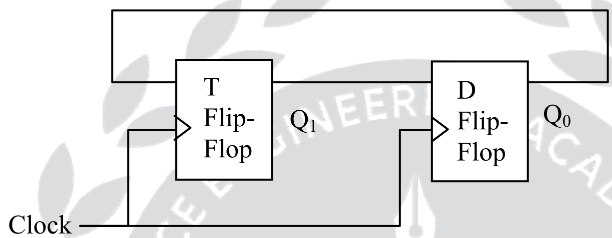
(C) x = 2, y = 2 (D) x = 1, y = 1

49. Ans: (D)

Sol: 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).

50. 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 Q_0 and Q_1 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_0 after the 3rd cycle are 00 and after the 4th cycle are 11 respectively

(D) Q_1 Q_0 after the 3rd cycle are 01 and after the 4th cycle are 01 respectively

50. Ans: (B)

Sol:

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

$T_1 = Q_0$

$D_0 = Q_1$

51. 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

51. Ans: (D)

Sol: (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.

$\therefore$ 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

52. 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______.

52. Ans: 1.51

Sol: For Naive pipelined CPU

K = 5, T_{seg} = 20 + 2 = 22 ns, n = 20.

Total time needed for 20 instructions

$= (5 + 20 - 1) \times 22 \text{ ns} = 24 \times 22 \text{ ns}$

$= 528 \text{ ns}$

For Efficient pipelined processor

T_{seg} = 12 + 2 = 14 ns; k = 6, n = 20

Total time for 20 instructions

$(6 + 20 - 1) \times 14 \text{ ns} = 350 \text{ ns}.$

$$\text{Speed up} = \frac{t_n}{t_e} = \frac{528}{350} = 1.50857$$

$$\cong 1.51$$

53. 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.

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

$T_2 \leftarrow CR \div T_1$

The number of rows in T_2 is ________.

53. Ans: 4

Sol: The output of T_1 is: CourseName
CA
CB
CC

The output of T_2 is: StudentName
SA
SC
SD
SF

54. 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

54. Ans: (A)

Sol: The algorithm is wound-wait deadlock prevention strategy, hence deadlock free. As the killed transaction restarting with same time stamp, it is starvation free.

55. 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)

55. Ans: (D)

Sol: 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.

General Aptitude

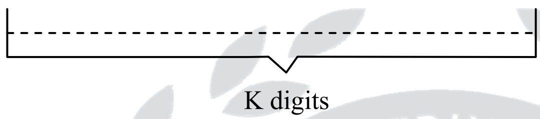
01. The probability that a k-digit number does NOT contain the digits 0, 5, or 9 is

(A) 0.3^k (B) 0.6^k

(C) 0.7^k (D) 0.9^k

01. Ans: (C)

Sol:



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 = $\left(\frac{7}{10}\right)^k = (0.7)^k$

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

(A) 24 (B) 27

(C) 32 (D) 36

02. Ans: (D)

Sol: Factorisation of 162 is $2 \times 3 \times 3 \times 3 \times 3$

$y \times 162$ is a perfect cube

$y \times 2 \times 3 \times 3 \times 3 \times 3$ = 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.,) $2 \times 2 \times 2 \times 3 \times 3 \times 3 \times 3 \times 3 \times 3$

$$y = 2 \times 2 \times 3 \times 3 = 4 \times 9 = 36$$

$\therefore$ The smallest number of y = 36.

03. Research in the workplace reveals that people work for many reasons _________.

(A) money beside (B) beside money

(C) money besides (D) besides money

03. Ans: (D)

Sol: ‘besides’ means in addition to.

04. 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?

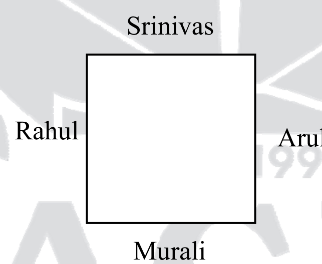
(A) Rahul and Murali (B) Srinivas and Arul

(C) Srinivas and Murali (D) Srinivas and Rahul

04. Ans: (C)

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

Rahul	Murali
Arul	Srinivas



$\therefore$ Srinivas and Murali are opposite to each other

05. 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

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10

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IN

10

Palak Bansal
IN

10

Nagesh Verma
PI

05. Ans: (C)

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

06. 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

06. Ans; (D)

Sol: Persons are Arun, Gulab, Neel and Shweta shirt colours are red, pink, blue and while

→ 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

07. 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

07. Ans: (A)

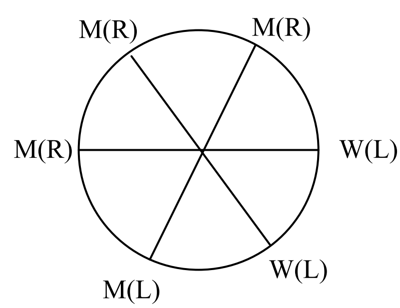
Sol: The total Number of peoples are sitting around a circular table is 6, in which atleast 2 men, atleast 2 women and atleast three right handed persons are compulsory. From this data, the following circular form is possible.

M = Male

W = Women

L = Left hand

R = Right hand



∴ The number of women on the table is 2.

08. "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

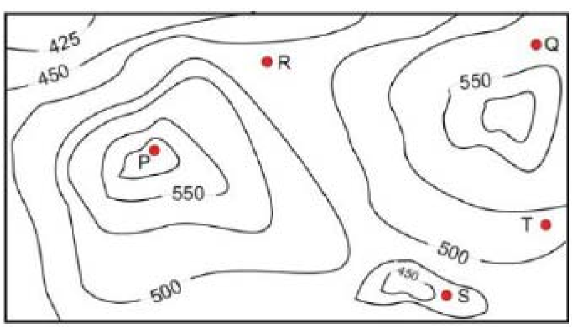
(C) Our colonial past never happened

(D) Nationalism has to be both adequately and properly imagined

08. Ans: (B)

Sol: To refer is to reach an opinion. The right opinion of the author is 'History is viewed through the filter of nationalism' so (B) is the right opinion of the author. The key words in the statement are 'history and nationalist imagination'.

09. 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 25m 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

09. Ans: (C)

Sol: 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. 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

10. Ans: (B)

Sol: $\frac{(x+y)+|x-y|}{2}$ …………….. (i)

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

if $-(x-y) = (y-x)$ when $y > x$

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

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

= minimum of (x, y)

as (x > y)

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

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

= minimum of (x, y)

as x < y

$\therefore$ Option (B) is correct.