GATE 2026

Computer Science-1

Forenoon Session

Memory Based
Questions & Solutions

Exam held on 08-02-2026

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SECTION - A GENERAL APTITUDE

Q.1 The Antonym of the word "Protagonist" is _____.

(a) Agnostic (b) Antagonist

(c) Anarchist (d) Arsonist

Ans. (b)

End of Solution

■■■■

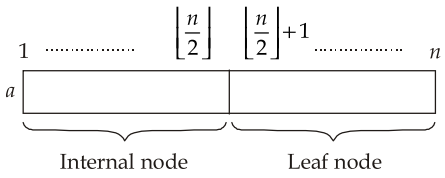
SECTION - B TECHNICAL

Q.2 Consider a heap containing n elements, where $n > 100$ and n is odd. Assuming 1-based indexing, which of the following cannot to be index of a leaf node in the heap?

(a) $\frac{(n-1)}{2}$ (b) $\frac{(n-3)}{2}$

(c) n (d) $\frac{(n+1)}{2}$

Ans. (a, b)



End of Solution

Q.3 $T_1(n) = 4T_1\left(\frac{n}{2}\right) + n^{\log_4 5}$

Which is true?

(a) $T_1(n) = \theta(n^2)$ (b) $T_1(n) = \theta(n^{\log_4 5})$

(c) $T_1(n) = \theta(n^{\log_4 5} \log n)$ (d) $T_1(n) = \theta(n^2 \log n)$

Ans. (a)

$$T(n) = 4T_1\left(\frac{n}{2}\right) + n^{\log_4 5}$$

By using Master theorem,

$$a = 4,\ b = 2$$

$$f(n) = n^{\log_4 5}$$

$$\log_b^a = \log_2^4 = 2$$

$$n\log_b^a = n^2$$

$$\log_4^5 = \frac{\log 5}{\log 4} \approx 1.16$$

So, $f(n) = n^{1.16} = O(n^{2-\epsilon})$

For some $\epsilon > 0$

$$f(n) = O\left(n^{\log_b^{a-\epsilon}}\right)$$

$$f(n) = \theta(n^{\log_b^a})$$

$$f(n) = \theta(n^2)$$

End of Solution

Q.4 Which of the following is always true for LL(1) parser?

(a) Grammar must be left factored

(b) LL(1) parser is more powerful than SLR(1).

(c) LL(1) is non back tracking.

(d) Grammar must be left recursive.

Ans. **(a, c)**

- LL(1) grammar must be left factored.
- LL(1) uses non-backtracking.
- Left recursive grammar can't be LL(1).
- If a grammar is LL(1) then it may or may not be SLR(1). Similarly if a grammar is SLR(1) it may or may not be LL(1).

End of Solution

Q.5 Consider the following grammar:

$S \rightarrow aSbS \mid bS \mid \in$

Which of the following is true?

(a) Grammar is ambiguous

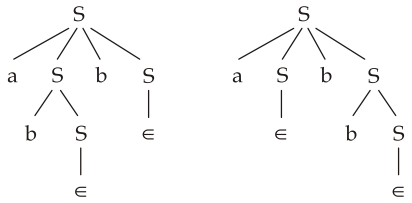
(b) abab is having only one parse tree

(c) abb is ambiguous string

(d) None of these

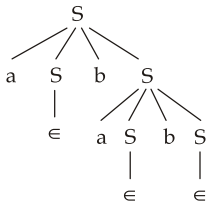
Ans. **(a, c)**

$$G = \{S \rightarrow aSbS \mid bS \mid \in\}$$



Here abb is having 2 different parse trees.

∴ The grammar is ambiguous.



abab has only one parse tree.

End of Solution

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Q.6 Consider the following C statement:

```
char * str1 = "Hello;        // stmt S1
char * str2 = "Hello";       // stmt S2
char * str3 = "Hello"        // stmt S3
```

Which of the following are correct?

(a) S_1 and S_2 are lexical errors
(b) S_2 is lexical and S_3 is semantic
(c) S_2 is syntax and S_3 is semantic
(d) S_1 is lexical and S_3 is syntax

Ans. (d)

Statement 1 is having unmatched string ∴ Lexical error
Statement 2 is not having any error
Statement 3 is not ending with semicolon ∴ Syntax error

End of Solution

Q.7 Which one of the following of register operands on different instructions can cause data hazard in the pipelined processor?

(a) Write After Read
(b) Write After Write
(c) Read After Read
(d) Read After Write

Ans. (a, b, d)

- True data dependency → RAW hazard
- Anti data dependency → WAR hazard
- Output data dependency → WAW hazard
- RAR is not a hazard because Read-Before-Read is not a dependency.

End of Solution

Q.8 Match the following List-I and List-II:

List-I	List-II
A. Immediate AM	1. Pointer
B. Base register	2. Constant
C. Indirect	3. Array element
D. Index	4. Position independent codes

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

Ans. (c)

- Immediate AM is used to access the constants.
- Indirect AM is used to implement the pointers.
- Indexed AM is used to access the arrays.
- Base register AM is used to write the position independent codes.

End of Solution

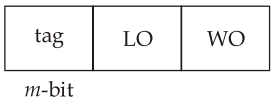
Q.9 **Consider a system with the following cache configuration:**
Block size = 128 bytes
Physical memory size = 2^{23} bytes
Cache size = 2^{13} bytes
Two cache organizations are used:
1. A direct-mapped cache with tag size = m bits.
2. A k-way set associative cache with tag size = n bits where

$$k = 2^L,\ L \in \{1, 2, 3, ...\}$$

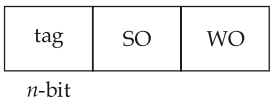
Which of the following relations between n and m is / are correct?
(a) $n = m - L$ **(b)** $n = m + L$
(c) $n = mL$ **(d)** $n = m + k$

Ans. (b)

Direct cache address format:



Set associative cache address format:



Here, N-value increases depends on the associativity of a cache.

i.e., $$S = \frac{\text{Number of lines}}{P\text{-way}} = \frac{\text{Number of lines}}{2^L} = 2^{(LO - L)}$$

So, index value decreases w.r.t. P-value.
$\therefore$ Tag space increases w.r.t. associativity.
Hence, $n = (m + L)$

End of Solution

Q.10 Consider the following single precision floating point numbers and the operation.

X : $(35C00000)_H$

Y : $(34A00000)_H$

$Z = X + Y$

What is the value of 'Z' in hexadecimal?

(a) $(B5E80000)_H$ (b) $(F5E80000)_H$

(c) $(35C80000)_H$ (d) $(35E80000)_H$

Ans. **(d)**

X : $(35C00000)_H$

0	011 0101 1	100 0000.....
S	BE	M

Bias: +127

Value: $(-1)^0 (1.1000\ .....) \times 2^{107\ -\ 127}$

$+ (1.1000\ .....) \times 2^{-20}$

Y : $(34A00000)_H$

0	011 0100 1	010 0000.....
S	BE	M

Bias: +127

Value: $(-1)^0 (1.010000\ .....) \times 2^{105\ -\ 127}$

$+ (1.010000\ .....) \times 2^{-22}$

Now align 'Y' to right 2 times

Y : $+ 0.0101000\ ..... \times 2^{-22\ +\ 2}$

Y : $+ 0.0101000\ ..... \times 2^{-20}$

$(X + Y)$:

$$\begin{array}{r} 1.100000..... \\ 0.010100..... \\ \hline 1.110100..... \end{array}$$

Z : $1.110100\ ..... \times 2^{-20}$

$BE = AE + Bias$

$= (-20) + (+127) = 107$

$= 01101011$

0	011 0101 1	110 10000.....
	3 5	E 8 0000

Answer is $(35E80000)_H$

End of Solution

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Q.11 Consider the following 8-bit signed integers x, y using sign-magnitude format is

$x = 10110100$

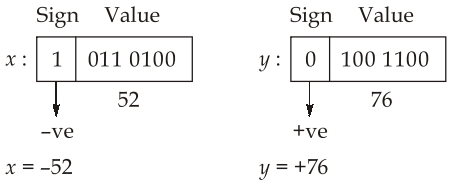
$y = 01001100$

Which of the following operations results overflow?

(a) $x - y$ **(b)** $x + y$

(c) $-x + y$ **(d)** $-x - y$

Ans. **(a, c)**



8 bit sign-magnitude range is

$\{-(2^{8-1} - 1)$ to $+ (2^{8-1} - 1)\}$

$\{-127$ to $+ 127\}$

(a) $(-52) - (+76)$

-128 (overflow)

(b) $-52 + (+76)$

$+24$

(c) $-(-52) + (+76)$

$+52 + 76$

$+128$ (overflow)

(d) $-(-52) - (+76)$

$52 - 76$

-24

End of Solution

Q.12 Which of the following is may not dependency preserving decomposition?

(a) 1NF **(b)** 2NF

(c) 3NF **(d)** BCNF

Ans. **(d)**

- Dependency preserving decomposition means that all functional dependencies of the original relation can be checked without joining the decomposed relations.
- Decompositions into 1NF, 2NF, and 3NF can always be made dependency preserving.
- However, decomposition into BCNF may require breaking a relation in such a way that some functional dependencies are lost and can only be verified by performing a join.

Hence, BCNF decomposition may not be dependency preserving.

End of Solution

Q.13 **Consider a relation R(A, B, C, D). The candidate keys of the relation are AB and AC. How many distinct superkeys does the relation R have?**

Ans. **(6)**

R(A, B, C, D)

Super of keys over AB = $2^2 = 4$

Super of keys over AC = $2^2 = 4$

Super of keys over ABC = $2^1 = 2$

Total number of super keys = $4 + 4 - 2 = 6$

End of Solution

Q.14 **Consider a relation R(A, B, C, D) and functional dependencies of $X \rightarrow Y$. Which of the following statement are correct?**

(a) **If $PQ \rightarrow R$, then $P \rightarrow R$ or $Q \rightarrow R$.**

(b) **If $P \rightarrow R$ and $Q \rightarrow S$, then $PQ \rightarrow RS$.**

(c) **If $P \rightarrow R$, then $PQ \rightarrow R$.**

(d) **If $PQ \rightarrow R$ and $P \rightarrow R$, then $Q \rightarrow R$.**

Ans. **(b, c)**

(a) If PQ → R, then P → R or Q → R

If attribute R depends on the combination of P and Q, it does not imply that P alone or Q alone can determine R.

So this does not follow from Armstrong's axioms. So, it is incorrect.

(b) If P → R and Q → S, then PQ → RS

By using augmentation and union:

From P → R, augment with Q : PQ → R

From Q → S, augment with P : PQ → S

Using union: PQ → RS

So, it is correct.

(c) If P → R, then PQ → R

By augmentation rule of functional dependencies: P → R ⇒ PQ → R

So, it is correct.

(d) If PQ → R and P → R, then Q → R

Even if P alone determines R, it does not imply that Q alone determines R.

There is no Armstrong axiom that allows this inference. So, it is incorrect.

End of Solution

Q.15 Consider two relational $R(P, Q)$ and $S(X, Y)$.
Given $E = \{u \mid \exists v\ \exists w$ such that $(u, v) \in R$ and $(v, w) \in S\}$
Which one of the following relational Algebra expressions is equivalent to E?

(a) $\pi_P(S \bowtie_{S.Y = R.Q} R)$
(b) $\pi_P(R \bowtie_{R.P = S.X} S)$
(c) $\pi_P(S \bowtie_{S.X = R.Q} R)$
(d) $\pi_P(S \bowtie_{R.P = S.Y} R)$

Ans. (c)

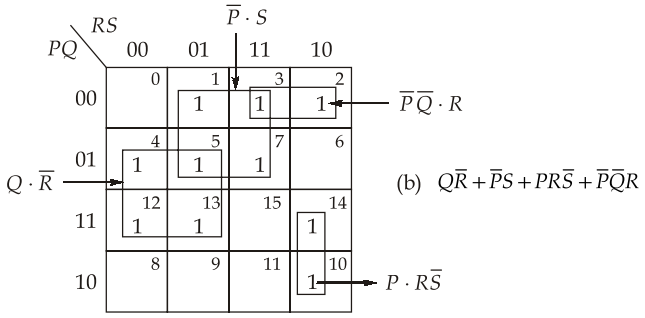
$u \ (v) \quad (v) \ w$
$R(P, Q)$ and $S(X, Y)$
$(u, v) \in R$ and $(v, w) \in S \implies \pi_P(R_{R.Q=S.X} \bowtie S)$

End of Solution

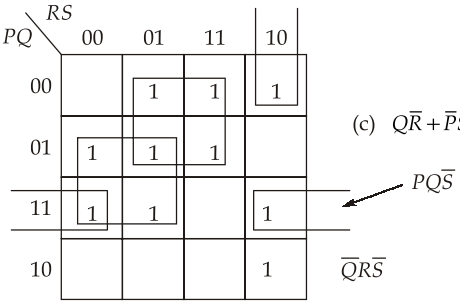
Q.16 $f(P, Q, R, S) = \sum m(1, 2, 3, 4, 5, 7, 10, 12, 13, 14)$.
Find SOP expression?

(a) $P\bar{S} + Q\bar{R} + \bar{P}\bar{Q}\bar{R} + \bar{Q}R\bar{S}$
(b) $P\bar{S} + Q\bar{R} + \bar{P}\bar{Q}R + PR\bar{S}$
(c) $\bar{P}S + Q\bar{R} + PQ\bar{S} + \bar{Q}R\bar{S}$
(d) $\bar{P}S + Q\bar{R} + PQ\bar{S} + PR\bar{S}$

Ans. (b, c)



(b) $Q\bar{R} + \bar{P}S + PR\bar{S} + \bar{P}\bar{Q}R$



(c) $Q\bar{R} + \bar{P}S + PQ\bar{S} + \bar{Q}R\bar{S}$

End of Solution

Q.17 $F(P,Q) = (\bar{P}+Q) \oplus \bar{P}Q$ is are

(a) $\bar{P} \oplus \bar{Q}$ (b) $\overline{P \oplus Q}$

(c) $P \oplus Q$ (d) $\bar{P} \oplus Q$

Ans. (b, d)

$$A \oplus B = \bar{A}B + A\bar{B} \text{ or } (\bar{A}+\bar{B})(A+B)$$

$$(\bar{P}+Q) \oplus \bar{P}Q \Rightarrow (\bar{P}+Q+\bar{P}Q)\cdot(P\bar{Q}+P+\bar{Q})$$

$$\Rightarrow (Q+\bar{P}(1+Q))\cdot(P(1+\bar{Q})+\bar{Q})$$

$$\Rightarrow (\bar{P}+Q)\cdot(P+\bar{Q})$$

$$\Rightarrow P \odot Q$$

Option (b) and (d) $\overline{P \oplus Q}$, $\bar{P} \oplus Q$

End of Solution

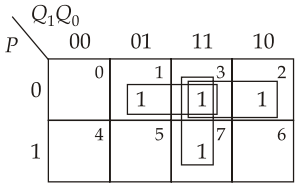
Q.18 Consider 2-bit saturating up/down counter for $p = 0$ and $p = 1$ respectively. Excitation D_1 and D_0 for given table:

P	Q_1	Q_0	Q_1^+	Q_0^+
0	0	0	0	1
0	0	1	1	0
0	1	0	1	1
0	1	1	1	1
1	0	0	0	0
1	0	1	0	0
1	1	0	0	1
1	1	1	1	0

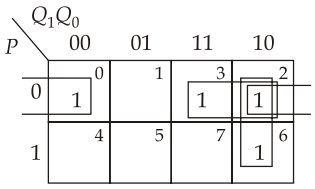
Find D_1 and D_0.

Ans. (Sol.)

P	Q_1	Q_0	Q_1^+	Q_0^+	D_1	D_0
0	0	0	0	1	0	1
0	0	1	1	0	1	0
0	1	0	1	1	1	1
0	1	1	1	1	1	1
1	0	0	0	0	0	0
1	0	1	0	0	0	0
1	1	0	0	1	0	1
1	1	1	1	0	1	0



$$D_1 = Q_1 \cdot Q_0 + \overline{P} \cdot Q_0 + \overline{P} \cdot Q_1$$



$$D_0 = Q_1 \cdot \overline{Q}_0 + \overline{P} \cdot \overline{Q}_0 + \overline{P} \cdot Q_1$$

End of Solution

Q.19 $f(x) = \left(\frac{|x|}{2} - x\right) \times \left(x - \frac{|x|}{2}\right)$

(a) f **has local minimum**

(b) f **has local maximum**

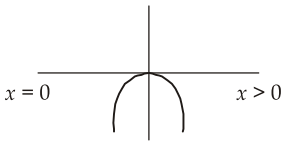
(c) f' **is continuous at** $x = 0$

(d) f' **is not differentiable at** $x = 0$

Ans. **(d)**

$$f(x) = \begin{cases} \left(-\frac{x}{2} - x\right)\left(x + \frac{x}{2}\right) & x < 0 \\ \left(\frac{x}{2} - x\right)\left(x - \frac{x}{2}\right) & x \geq 0 \end{cases}$$

$$f(x) = \begin{cases} -\frac{9}{4}x^2 & x < 0 \\ -\frac{x^2}{4} & x \geq 0 \end{cases}$$

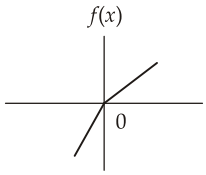


it continuous and smooth.

$\therefore$ $f(x)$ is differentiable at $x = 0$

$\Rightarrow$ $f'(x)$ is continuous at $x = 0$

$$f'(x) = \begin{cases} -\frac{18}{4}x & x < 0 \\ -\frac{x}{2} & x \geq 0 \end{cases}$$



$$f''(x) = \begin{cases} -\frac{9}{2} & x < 0 \\ -\frac{1}{2} & x \geq 0 \end{cases}$$

is not continuous at $x = 0$

$\therefore$ f' is not differentiable at $x = 0$

End of Solution

Q.20 **For $n > 1$, the maximum multiplicity of any eigen value of an $n \times n$ matrix with real entries is?**

(a) $n - 1$ **(b)** $n + 1$

(c) n **(d)** 1

Ans. **(c)**

For $n > 1$, multiplicity of λ = arithmetic mean of λ.

Any λ can repeat maximum 'n' number of times.

End of Solution

Q.21 $$f(x) = \begin{cases} C_1 e^x - C_2 \log e\left(\frac{1}{x}\right), & x > 0 \\ 3, & \text{otherwise} \end{cases}$$

Where $C_1, C_2 \in IR$

If f is continuous at $x = 0$ then $C_1 + C_2$ is _____.

Ans. **(3)**

$$f(x) = \begin{cases} C_1 e^x - C_2 \log x, & x > 0 \\ 3, & x \leq 0 \end{cases}$$

$\because$ $f(x)$ is continuous at $x = 0$

$$\lim_{x \to 0} f(x) = 3$$

$$\lim_{x \to 0} C_1 e^x + C_2 \log x = 3$$

$$C_1 + C_2 \log 0 = 3$$

Possible if $C_2 = 0$

$\therefore$ $C_2 = 0,\ C_1 = 3$

$$C_1 + C_2 = 3$$

End of Solution

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Q.22 An unbiased six faced dice whose faces are marked with 1, 2, 3, 4, 5 and 6 is rolled twice. The probability that the number appearing in the second roll is an integer multiple of the number appearing in the first roll?

(a) $\frac{1}{6}$ (b) $\frac{5}{18}$

(c) $\frac{7}{18}$ (d) $\frac{5}{6}$

Ans. (c)

$$E_2 = kE_1,\ k \in Z$$

If $E_1 = 1 \Rightarrow E_2 = 1, 2, 3, 4, 5, 6$

If $E_1 = 2 \Rightarrow E_2 = 2, 4, 6$

If $E_1 = 3 \Rightarrow E_2 = 3, 6$

If $E_1 = 4 \Rightarrow E_2 = 4$

If $E_1 = 3 \Rightarrow E_2 = 5$

If $E_1 = 6 \Rightarrow E_2 = 6$

$$\therefore P(E_2 = kE_1) = P(E_1 = 1) + P(E_1 = 2) + P(E_1 = 3) + P(E_1 = 4) + P(E_1 = 5) + P(E_1 = 6)$$

$$= \frac{6}{36} + \frac{3}{36} + \frac{2}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36}$$

$$= \frac{14}{36} = \frac{7}{18}$$

End of Solution

Q.23 *Anxn*, $n > 1$

If (1, 0, 1, 0, 0 .... 0) $\in R^n$ belongs to the null space of A then

(a) $|A| = 0$

(b) $|A| = 1$

(c) Rank $A = 1$

(d) There are at least 2 non zero vectors in the null space of A.

Ans. (a, d)

$X = (1, 0, 1, 0, 0 .... 0)^T \in$ null space of $Ax = 0$

which is non-zero sequence, so it is one of the only many sequence

$\Rightarrow |A| = 1$

End of Solution

Q.24 There are 5 processes in a system.
The maximum number of records a process can take is 2.
At a time, a process can take only a single resource and can free only a single resource.
How many records are required to ensure deadlock-free execution _____?

Ans. (6)

P_1	P_2	P_3	P_4	P_5
1	1	1	1	1

1
= 6

or

$$m = n \times (R - 1) + 1$$
$$= 5 \times (2 - 1) + 1$$
$$\Rightarrow \quad 5 + 1 = 6$$

End of Solution

Q.25 Consider TLB, cache and MMU with paging. Which is never be true?
(a) TLB miss, PT hit, cache hit
(b) TLB miss, PT miss, cache miss
(c) TLB miss, PT miss, cache hit
(d) TLB hit, PT miss, cache hit

Ans. (c, d)

- Possible case. On a TLB miss, the page table is accessed and found in memory (PT hit). The required data block may already be present in cache.
- Possible case. TLB miss leads to page table access, and PT miss causes a page fault. Since the page is not in memory, the cache also misses.
- Not possible. A PT miss means the page is not in main memory. If the page is not in memory, its data cannot be present in cache.
- Not possible. A TLB hit implies the page table entry is already available. Therefore, a PT miss cannot occur after a TLB hit.

End of Solution

Q.26 Consider the following program:

```
int bar(int n)
{
    if(n == 1) return 0;
    else
    return 1 + bar(n/2);
}
int foo(int n)
{
    if (n == 0) return 0;
    else
    return 1 + foo(bar(n));
}
```

Smallest value of 'n' for which foo(n) = 5?

Ans. (2^{16})

$\text{bar}(n) = \lfloor \log_2 n \rfloor \text{foo}(2^{16})$

$$\begin{aligned}\text{foo}(n) &= 1 + \text{foo}(\text{bar}\ (2^{16})) \\ &= 1 + \text{foo}(16) \\ &= 1 + 1 + \text{foo}\ (\text{bar}\ (16)) \\ &= 1 + 1 + \text{foo}\ (4) \\ &= 1 + 1 + 1 + \text{foo}\ (\text{bar}\ (4)) \\ &= 1 + 1 + 1 + \text{foo}\ (2) \\ &= 1 + 1 + 1 + 1 + \text{foo}\ (\text{bar}\ (2)) \\ &= 1 + 1 + 1 + 1 + \text{foo}\ (1) \\ &= 1 + 1 + 1 + 1 + 1 + \text{foo}\ (\text{bar}\ (1)) = 5\end{aligned}$$

End of Solution

Q.27 Consider the following program, what is the output printed _____?

```
void f(int i, int j)
{
if (i < j)
{
    i = 0;
    while (i < 10)
    {
        j = j + 2;
        i++;
    }
    printf(i);
}
}
int main( )
{
    int i = 9, int j = 10;
        f(i, j);
        return 0;
}
```

Ans. (10)

f(9, 10)

if (9 < 10) ⟹ True

i 0 ~~1~~ ~~2~~ ~~3~~ ~~4~~ ~~5~~ ~~6~~ ~~7~~ ~~8~~ ~~9~~ 10

j 10 ~~12~~ ~~14~~ ~~16~~ ~~18~~ ~~20~~ ~~22~~ ~~26~~ ~~27~~ ~~28~~ 30

printf('"%d', i) = 10

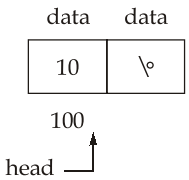
End of Solution

Q.28 Count the number of nodes in the linked list which is not empty?

```
struct node
{
    int value;
    struct node * next;
}
fun (node * head)
{
    if (E1) return 1;
    else
    E2;
}
```

(a) E1: head == Null, E2: 1 + fun (head);
(b) E1: head == Null, E2: 1 + fun (head → next);
(c) E1: head → next == Null, E2: 1 + fun (head → next);
(d) None of these

Ans. (c)



When head → next == Null, we are at the last node contributed exactly 1.
Otherwise, count current node (1) + remaining list.

End of Solution

Q.29 Which of the following cannot be the number of states in the minimal DFA equivalent to the NFA of 6 states is

(a) 1
(b) 32
(c) 65
(d) 128

Ans. (c, d)

The maximum number of states of a DFA equivalent to NFA of n states in 2^n.
Here NFA has 6 states.
$\therefore$ The DFA cannot have more than 2^6 states.

End of Solution

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Q.30 If $L_1 \cap L_2$ and L_2 are regular than which of the following is always true?

(a) $\bar{L}_1$ is CFL
(b) L_1 is Regular
(c) $L_1 \cup L_2$ is regular
(d) $\bar{L}_2$ is CFL

Ans. (d)

If $L_1 \cap L_2$ is regular then L_1 and L_2 are need not be regular.

Here given L_2 is regular.

$\Rightarrow$ $\bar{L}_2$ is also regular.

$\Rightarrow$ $\bar{L}_2$ is also CFL.

End of Solution

Q.31 Sliding window protocol:

L = 1000 bits

R = 100 Kbps

T_p = 100 ms

T_{pm} = 0

Find optimal window size?

(a) 10
(b) 11
(c) 20
(d) 21

Ans. (c)

Transmission time of one frame

$$T_t = \frac{L}{R} = \frac{1000}{100 \times 10^3} = 0.01 \text{ s} = 10 \text{ ms}$$

Round Trip Time (RTT)

$$\text{RTT} = 2T_p + T_{pm} = 2 \times 100 = 200 \text{ ms}$$

Optimal window size

$$W_{\text{opt}} = \frac{\text{RTT}}{T_t}$$

$$W_{\text{opt}} = \frac{200}{10} = 20$$

End of Solution

Q.32 Which of the following is correct about the TCP connection?

(a) Two-way handshaking.
(b) TCP is half duplex.
(c) The server can't initiate closing of connection before client.
(d) Client and server initiate closing connection at same time.

Ans. (d)

End of Solution

Q.33 An ISP having Address Block 202.16.0.0/15. Assign a Block of 6000 IP Address to a client using the Classless Addressing. Which of the following Address Block can be assigned by the ISP?

(a) 202.16.32.0/19
(b) 202.16.0.0/19
(c) 202.17.24.0/19
(d) 202.17.64.0/19

Ans. (a, b, d)

End of Solution

■■■■

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