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GATE 2019
Computer Science & IT

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Questions and Solutions

Date of Exam : 3/2/2019

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GENERAL APTITUDE

Q.1 Two cars start at the same time from the same location and go in the same direction. The speed of the first car is 50 km/h and the speed of the second car is 60 km/h. The number of hours it takes for the distance between the two cars to be 20 km is _____.

(a) 1 (b) 2

(c) 3 (d) 6

Ans. **(b)**

Speed of car A = 50 km/hr

Speed of car B = 60 km/hr

Since, both cars A and B are moving in same direction, the relative speed = 60 – 50 = 10 km/hr

Distance required between them = 20 km

$$\therefore \quad \text{Time} = \frac{\text{Distance}}{\text{Speed}} = \frac{20}{10} = 2 \text{ hrs}$$

End of Solution

Q.2 The expenditure on the project _____ as follows; equipments Rs. 20 lakhs, salaries Rs. 12 lakhs, and contingency Rs.3 lakhs.

(a) break (b) breaks

(c) breaks down (d) break down

Ans. **(c)**

'Breaks down' is a transitive phrasal verb which means to divide something such as a total amount into separate parts.

Option (c) is most appropriate.

End of Solution

Q.3 Ten friends planned to share equally the cost of buying a gift for their teacher. When two of them decided not to contribute, each of the other friends had to pay Rs. 150 more. The cost of the gift was Rs. _____.

(a) 12000 (b) 6000

(c) 3000 (d) 666

Ans. **(b)**

Let share of each student = x

Total cost of gift = $10 \times x$

$x = 8(x + 150)$

$x = 600$

Total cost = $10 \times 600 = 6000$

End of Solution

Q.4 A court is to a judge as _____ is to a teacher.

(a) a syllabus (b) a school

(c) a student (d) a punishment

Ans. **(b)**

A 'court' is for a 'judge' as a 'school' is for a 'teacher'.

Court is a place where a judge works.

Similarly, school is a place where a teacher works.

End of Solution

Q.5 The search engine's business model _____ around the fulcrum of trust.

(a) plays (b) bursts

(c) revolves (d) sinks

Ans. **(c)**

The search engine business model revolves around the fulcrum of trust.

Fulcrum is any thing that plays a central or essential role in an activity, event, or situation.

Thus, out of the given options, 'revolves' is the most appropriate.

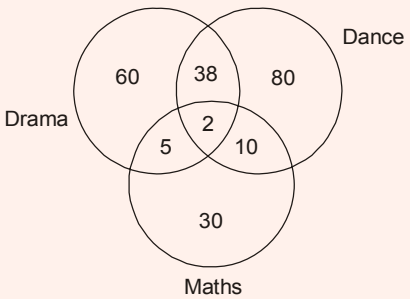
End of Solution

Q.6 In a college, there are three student clubs. Sixty students are only in the Drama club. 80 students are only in the Dance club, 30 students are only in the Maths club. 40 students are in both Drama and Dance clubs. 12 students are in both Dance and Maths clubs, 7 students are in both Drama and Maths clubs, and 2 students are in all the clubs. If 75% of the students in the college are not in any of these clubs, then the total number of students in the college is _____.

(a) 225 (b) 1000

(c) 975 (d) 900

Ans. **(d)**



Total number of students = 60 + 80 + 30 + 38 + 5 + 10 + 2 = 225

$$25\% = 225$$

$$\Rightarrow \quad 100\% = \frac{225}{25} \times 100 = 900$$

End of Solution

Q.7 The police arrested four criminals – P, Q, R and S. The criminals knew each other. They made the following statements:
P says "Q committed the crime."
Q says "S committed the crime."
R says "I did not do it."
S says "What Q said about me is false."
Assume only one of the arrested four committed the crime and only one of the statements made above is true. Who committed the crime?
(a) R (b) P
(c) S (d) Q

Ans. **(a)**

Suffix C as criminal, NC as not criminal.

Case I:

Criminals	P	Q	R	S
Assumption	T	F	F	F
Result	Q_C	S_{NC}	R_C	S_C

Q and R are criminal in the result is impossible because only one person committed the crime.

Case II:

Criminals	P	Q	R	S
Assumption	F	T	F	F
Result	Q_{NC}	S_C	R_C	S_C

S and R are criminal in the result is impossible because only one person committed the crime.

Case III:

Criminals	P	Q	R	S
Assumption	F	F	T	F
Result	Q_{NC}	S_{NC}	R_{NC}	S_C

S_{NC} and S_C in the result which is contradiction. [S committed crime and same time not committed crime which is contradiction]

Case IV:

Criminals	P	Q	R	S
Assumption	F	F	F	T
Result	Q_{NC}	S_{NC}	R_C	S_{NC}

R is criminal in the result.
Hence this case satisfies only one person committed the crime.
So option (a) is correct.

End of Solution

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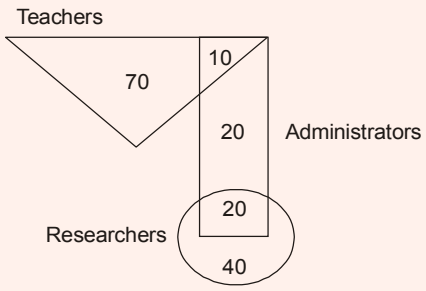
Q.8 In the given diagram, teachers are represented in the triangle, researchers in the circle and administrators in the rectangle. Out of the total number of the people, the percentage of administrators shall be in the range of _____.



(a) 46 to 60
(b) 0 to 15
(c) 31 to 45
(d) 16 to 30

Ans. (c)

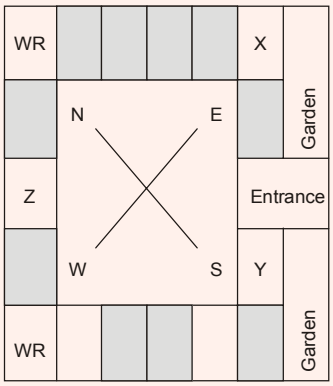
$$\text{Percentage of Administrators} = \frac{\text{Administrators}}{\text{Total}} \times 100$$

$$= \frac{50}{160} \times 100 = 31.25$$

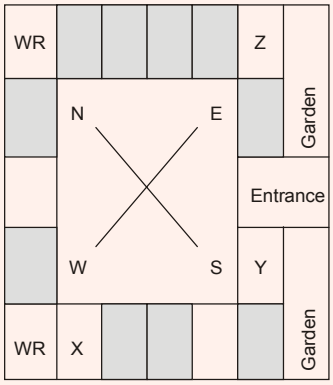
End of Solution

Q.9 Three of the five students allocated to a hostel put in special requests to the warden. Given the floor plan of the vacant rooms, select the allocation plan that will accommodate all their requests.
Request by X : Due to pollen allergy. I want to avoid a wing next to the garden.
Request by Y : 1 want to live as far from the washrooms as possible, since I am very sensitive to smell.
Request by Z : I believe in Vaastu and so want to stay in the South-West wing.
The shaded rooms are already occupied. WR is washroom.

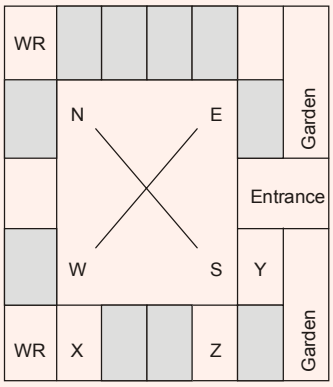
(a)



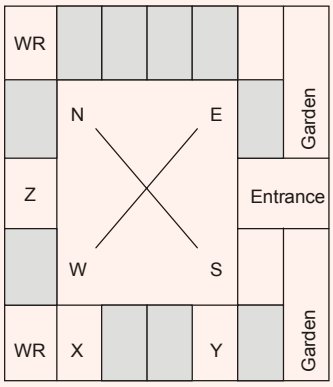
(b)



(c)



(d)



Ans. **(c)**

End of Solution

Q.10 "A recent High Court judgement has sought to dispel the idea of begging as a disease — which leads to its stigmatization and criminalization — and to regard it as a symptom. The underlying disease is the failure of the state to protect citizens who fall through the social security net".

Which one of the following statements can be inferred from the given passage?

(a) Begging is an offence that has to be dealt with firmly

(b) Beggars are created because of the lack of social welfare schemes

(c) Begging has to be banned because it adversely affects the welfare of the state

(d) Beggars are lazy people who beg because they are unwilling to work

Ans. **(b)**

The passage states that the underlying disease behind begging is the failure of the state to protect citizens who fall through the social security net.

Only option (b) can be inferred from this.

End of Solution

■■■■

COMPUTER SCIENCE

Q.1 A certain processor uses a fully associative cache of size 16 kB. The cache block size is 16 bytes. Assume that the main memory is byte addressable and uses a 32-bit address. How many bits are required for the Tag and the Index fields respectively in the addresses generated by the processor?

(a) 28 bits and 0 bits
(b) 24 bits and 0 bits
(c) 28 bits and 4 bits
(d) 24 bits and 4 bits

Ans. (a)

Cache memory size = 16 kB

Block size = 16 B

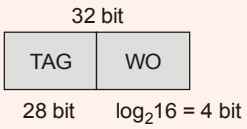
Main memory address = 32 bit

$$\text{Number of lines (N)} = \frac{16\text{ K}}{16} \Rightarrow \frac{2^{14}}{2^4} = 2^{10}$$

Fully associative cache memory (N-way)

$$\text{So, number of sets (S)} = \frac{\text{N}}{\text{P-way}} \Rightarrow \frac{2^{10}}{2^{10}} = 1$$

$\therefore$ Address format:



So, TAG = 28 bit

Index = 0 bit (No address)

End of Solution

Q.2 Let G be an undirected complete graph, on n vertices, where $n > 2$. Then, the number of different Hamiltonian cycles in G is equal to

(a) $n!$ (b) $(n-1)!$

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

Ans. **(d)**

In a complete graph we can traverse the n vertices in any order and return to the starting vertex and form a Hamiltonian cycle. The number of such cycles will be $n!$

However, since circular rotations will have to ignored. Since for example K_4 with vertices {1, 2, 3, 4}, the cycle 1-2-3-4 is same as 2-3-4-1 is same as 3-4-1-2 etc. we now get only $(n-1)!$ distinct Hamiltonian cycles. Further, the cycle 1-2-3-4 and 1-4-3-2 are also same (clockwise and anticlockwise).

So ignoring this orientation also we finally get $\frac{(n-1)!}{2}$ distinct Hamiltonian cycles which is option (d).

End of Solution

Q.3 Consider the grammar given below:

$S \rightarrow Aa$

$A \rightarrow BD$

$B \rightarrow b \mid \in$

$D \rightarrow d \mid \in$

Let a, b, d and $ be indexed as follows:

a	b	d	$
3	2	1	0

Compute the FOLLOW set of the non-terminal B and write the index values for the symbols in the FOLLOW set in the descending order. (For example, if the FOLLOW set is {a, b, d, $}, then the answer should be 3210)

Ans. **(31)**

$S \rightarrow Aa$

$A \rightarrow BD$

$B \rightarrow b \mid \in$

$D \rightarrow d \mid \in$

Follow (B) = {d, a}

Hence their index in descending order is 31.

End of Solution

Q.4 Consider a sequence of 14 elements: A = [–5, –10, 6, 3, –1, –2, 13, 4, –9, –1, 4, 12, –3, 0]. The subsequence sum $S(i, j) = \sum_{k=1}^{j} A[k]$. Determine the maximum of $S(i, j)$, where $0 \le i \le j < 14$. (Divide and conquer approach may be used.)

Ans. (29)

End of Solution

Q.5 Consider the following C program:

```
#include <stdio.h>
int main ( ) {
    int arr[ ] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 0, 1, 2, 5}, *ip = arr + 4;
    printf ("%d\n", ip[1])'
    return 0;
}
```

The number that will be displayed on execution of the program is _____.

Ans. (6)

End of Solution

Q.6 Two numbers are chosen independently and uniformly at random from the set {1, 2, ...,13}. The probability (rounded off to 3 decimal places) that their 4-bit (unsigned) binary representations have the same most significant bit is _____.

Ans. (0.503)

End of Solution

Q.7 In 16-bit 2's complement representation, the decimal number –28 is:

(a) 1111 1111 0001 1100 (b) 1111 1111 1110 0100

(c) 0000 0000 1110 0100 (d) 1000 0000 1110 0100

Ans. (b)

+28 ⇒ 0000 0000 0001 1100

–28 ⇒ 1111 1111 1110 0100 (2's complement form)

End of Solution

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Q.8 Which one of the following is NOT a valid identity?

(a) $x \oplus y = (xy + x'y')'$ (b) $x \oplus y = x + y$, if $xy = 0$

(c) $(x \oplus y) \oplus z = x \oplus (y \oplus z)$ (d) $(x + y) \oplus z = x \oplus (y + z)$

Ans. **(d)**

(a) $x \oplus y = (xy + x'y')'$

$= (x \odot y)'$

$= x \oplus y$, it is valid.

(b) $x \oplus y = (x + y)(\bar{x} + \bar{y})$

$= (x + y)\overline{xy}$

$= (x + y)\bar{0}$

$= (x + y)$, so it is valid.

(c) $(x \oplus y) \oplus z = x \oplus (y \oplus z)$

Associativity is true on Ex-OR operator so it valid.

(d) $(x + y) \oplus z = \overline{(x+y)} \cdot z + (x+y)\bar{z}$

$= \bar{x}\bar{y}z + x\bar{z} + y\bar{z}$

1 4,6 2,6

$= \sum m(1, 2, 4, 6)$

$x \oplus (y + z) = \bar{x}(y+z) + x\overline{(y+z)}$

$= \bar{x}y + \bar{x}z + x\bar{y}\bar{z}$

2,3 1,3 4

$= \sum m(1, 2, 3, 4)$

$(x + y) \oplus z \neq x \oplus (y + z)$

So option (d) is invalid.

End of Solution

Q.9 Which one of the following kinds of derivation is used by LR parsers?

(a) Rightmost (b) Rightmost in reverse

(c) Leftmost (d) Leftmost in reverse

Ans. **(b)**

LR parser is a bottom up parser. Hence it uses right most derivation in reverse order.

So option (b) is the correct answer.

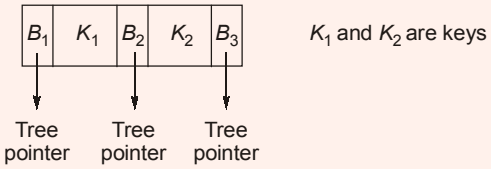
End of Solution

Q.10 Which one of the following statements is NOT correct about the B^+ tree data structure used for creating an index of a relational database table?

(a) Key values in each node are kept in sorted order
(b) Each leaf node has a pointer to the next leaf node
(c) B^+ tree is a height balanced tree
(d) Non-leaf nodes have pointers to data records

Ans. (d)

- B^+ tree non leaf node have pointer to data records is false statement.
- B^+ tree non leaf node consists of only keys and tree pointers (node pointers).
- Below is the structure of B^+ tree non leaf node



End of Solution

Q.11 The value of 3^{51} mod 5 is _____.

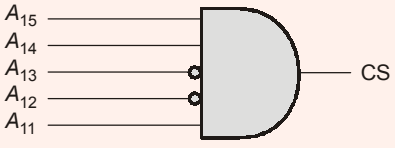
Ans. (2)

By Fermat's theorem

$$3^{(5-1)} \bmod 5 = 1$$
$$3^4 \bmod 5 = 1$$
$$3^{51} \bmod 5 = (3^4)^{12} \cdot 3^3 \bmod 5$$
$$= 3^3 \bmod 5$$
$$= 2$$

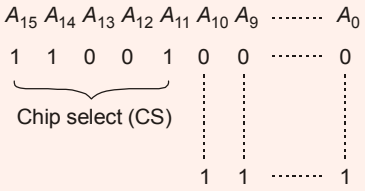
End of Solution

Q.12 The chip selects logic for a certain DRAM chip in memory system design is shown below. Assume that memory has 16 address lines denoted by A_{15} to A_0. What is the range of addresses (in hexadecimal) of the memory system that can get enabled by the chip select (CS) signal?



(a) DA00 to DFFF
(b) C800 to CFFF
(c) C800 to C8FF
(d) CA00 to CAFF

Ans. (b)



[C800 to CFFF]

End of Solution

Q.13 Let X be a square matrix. Consider the following two statements on X.

I. X is invertible.

II. Determinant of X is non-zero.

Which one of the following is TRUE?

(a) I implies II; II does not imply I.
(b) II implies I; I does not imply II.
(c) I and II are equivalent statements.
(d) I does not imply II; II does not imply I.

Ans. (c)

Both I and II are equivalent statements.

End of Solution

Q.14 Consider the following C program:

```
#include <stdio.h>
int jumble(int x, int y) {
    x = 2 * x + y;
    return x;
}
int main ( ) {
    int x = 2, y = 5;
    y = jumble(y, x);
    x = jumble(y, x);
    printf("%d\n", x);
    return 0;
}
```

The value printed by the program is _____.

Ans. (26)

End of Solution

Q.15 Which of the following protocol pairs can be used to send and retrieve e-mails (in that order)?

(a) IMAP, SMTP
(d) SMTP, MIME
(c) IMAP, POP3
(d) SMTP, POP3

Ans. **(d)**

SMTP is push protocol and to send email and POP3 is pull protocol i.e. to retrieve email.

End of Solution

Q.16 Let U = {1, 2, ..., n} and A = {(x, X), $x \in$ X and X $\subseteq$ U}. Consider the following two statements on $|A|$.

I. $|A| = n.2^{n-1}$

II. $|A| = \sum_{k=1}^{n} k \cdot \binom{n}{k}$

Which of the following is correct?

(a) Both I and II
(b) Neither I nor II
(c) Only II
(d) Only I

Ans. **(a)**

$$A = \{(x, X),\ x \in X \text{ and } X \subseteq U\}$$

The number of k element subsets of a set U with n elements $= \binom{n}{k} = {}^{n}C_{k}$.

The number of possible ordered pairs (x, X) where $x \in$ X is $k \cdot {}^{n}C_{k}$ for a given value of k from 1 to n.

So total number of ordered pairs in A

$$= |A| = \sum_{k=1}^{n} k \cdot {}^{n}C_{k} = \sum_{k=1}^{n} k \cdot \binom{n}{k}$$

So II is correct.

(Note that k = 0 is excluded since empty set has no elements and cannot form an order pair such as (x, X)).

But since by the combinational identity

$$\sum_{k=1}^{n} k \cdot \binom{n}{k} = n.2^{n-1}$$

So I is also correct.

So both I and II are correct.

End of Solution

Q.17 Consider the following two statements about database transaction schedules:

I. Strict two-phase locking protocol generates conflict serializable schedules that are also recoverable.

II Timestamp-ordering concurrency control protocol with Thomas' Write Rule can generate view serializable schedules that are not conflict serializable.

Which of the above statements is/are TRUE?

(a) Neither I nor II (b) I only

(c) II only (d) Both I and II

Ans. **(d)**

I. Strict 2PL guaranteed conflict serializable because of 2PL condition and also strict recoverable.

II. Thomas Write time stamp ordering ensures serializable. Thomas write rule time stamp ordering allowed to execute schedule which is view equal serial schedule based on time stamp ordering.

End of Solution

Q.18 For $\Sigma = \{a, b\}$, let us consider the regular language $L = \{x \mid x = a^{2+3k}$ or $x = b^{10+12k}$, $k \geq 0\}$. Which one of the following can be a pumping length (the constant guaranteed by the pumping lemma) for L?

(a) 9 (b) 24

(c) 3 (d) 5

Ans. **(b)**

$$L = \{a^{2+3k} \text{ or } b^{10+12k}\} \text{ for } k \geq 0$$
$$= a^2 (a^3)^* \text{ or } b^{10} (b^{12})^*$$
$$= \{a^2, a^5, a^8, \ldots, b^{10}, b^{22}, b^{34} \ldots..\}$$

The pumping length is p, than for any string $w \in L$ with $|w| \geq p$ must have a repetition i.e. such a string must be breakable into $w = xyz$ such that $|y| \geq 0$ and y can be pumped indefinitely, which is same as saying $xyz \in L \Rightarrow xy^*z \in L$.

The minimum pumping length in this language is clearly 11, since b^{10} is a string which has no repetition number, so upto 10 no number can serve as a pumping length. Minimum pumping length is 11. Any number at or above minimum pumping length can serve as a pumping length. The only number at or above 11, in the choice given is 24. So correct answer is option (b).

End of Solution

Q.19 Consider the following C program is executed on a Unix/Linux system:

```
#include<unistd.h>
int main( )
{
    int i;
    for (i = 0; i < 10; i++)
        if (i % 2 == 0) fork( );
    return 0;
}
```

The total number of child processes created is _____.

Ans. (31)

End of Solution

Q.20 If L is a regular language over $\Sigma = \{a, b\}$, which one of the following languages is NOT regular?

(a) $L \cdot L^R \{xy \mid x \in L, y^R \in L\}$

(b) Suffix $(L) = \{y \in \Sigma^* \mid \exists x \in \Sigma^*$ such that $xy \in L\}$

(c) Prefix $(L) = \{x \in \Sigma^* \mid \exists y \in \Sigma^*$ such that $xy \in L\}$

(d) $\{ww^R \mid w \in L\}$

Ans. (d)

- If L is regular, $L \cdot L^R$ is also regular by closure property.
- Suffix (L) and Prefix (L) are also regular by closure property.

However option (d) $\{ww^R \mid w \in L\}$ need not be regular since if L is an infinite regular language, then $\{ww^R \mid w \in L\}$ will not only be infinite, but also non-regular. Since it involves string matching and we can increase in length indefinitely and then finite automata FA will run out of memory.

So answer is option (d).

End of Solution

Q.21 An array of 25 distinct elements is to be sorted using quicksort. Assume that the pivot element is chosen uniformly at random. The probability that the pivot element gets placed in the worst possible location in the first round of partitioning (rounded off to 2 decimal places) is _____.

Ans. (0.08)

End of Solution

Q.22 Consider three concurrent processes P1, P2 and P3 as shown below, which access a shared variable D that has been initialized to 100.

P1	P2	P3
D = D + 20	D = D – 50	D = D + 10

The processes are executed on a uniprocessor system running a time-shared operating system. If the minimum and maximum possible values of D after the three processes have completed executed are X and Y respectively, then the value of Y – X is _____.

Ans. (80)

End of Solution

Q.23 Consider Z = X – Y, where X, Y and Z are all in sign-magnitude form. X and Y are each represented in *n* bits. To avoid overflow, the representation of Z would require a minimum of:

(a) $n + 2$ bits
(b) n bits
(c) $n - 1$ bits
(d) $n + 1$ bits

Ans. (d)

For example:

Let, $\left.\begin{matrix} X = +6, & n = 4 \\ Y = -5, & n = 4 \end{matrix}\right\} \Rightarrow (X - Y) = +11$

So Z = 11 which required 5 bits which is $(n + 1)$ bits

End of Solution

Q.24 Compute $\lim_{x\to 3} \frac{x^4 - 81}{2x^2 - 5x - 3}$

(a) $\frac{108}{7}$ (b) $\frac{53}{12}$

(c) 1 (d) Limit does not exists

Ans. **(a)**

$$\lim_{x\to 3} \frac{x^4 - 81}{2x^2 - 5x - 3} = \frac{0}{0} \text{ form. So apply L'H rule}$$

$$\lim_{x\to 3} \frac{4x^3}{4x - 5} = \frac{108}{7}$$

End of Solution

Q.25 Let G be an arbitrary group. Consider the following relations on G:

R_1: $\forall a, b \in G, a\, R_1\, b$ if and only if $\exists g \in G$ such that $a = g^{-1}bg$

R_2: $\forall a, b \in G, a\, R_2\, b$ if and only if $a = b^{-1}$

Which of the above is/are equivalence relation/relations?

(a) R_1 and R_2 (b) R_1 only

(c) R_2 only (d) Neither R_1 nor R_2

Ans. **(b)**

R_1: $\forall a, b \in G, a\, R_1\, b$ if and only if $\exists g \in G$ such that $a = g^{-1}bg$

Reflexive: $a = g^{-1}ag$ can be satisfied by putting $g = e$, identity "e" always exists in a group.

So reflexive

Symmetric: $aRb \Rightarrow a = g^{-1}bg$ for some g

$\Rightarrow b = gag^{-1} = (g^{-1})^{-1} ag^{-1}$

g^{-1} always exists for every $g \in G$.

So symmetric

Transitive: aRb and $bRc \Rightarrow a = g_1^{-1}bg_1$ and $b = g_2^{-1} cg_2$ for some $g_1 g_2 \in G$.

Now $a = g_1^{-1} g_2^{-1} cg_2 g_1 = (g_2 g_1)^{-1} cg_2 g_1$

$g_1 \in G$ and $g_2 \in G \Rightarrow g_2 g_1 \in G$ since group is closed so aRb and $aRb \Rightarrow aRc$ hence transitive

Clearly R_1 is equivalence relation.

R_2 is not equivalence it need not even be reflexive, since $aR_2\, a \Rightarrow a = a^{-1}$ $\forall a$ which not be true in a group.

R_1 is equivalence relation is the correct answer.

End of Solution

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Q.26 Consider the augmented grammar given below:

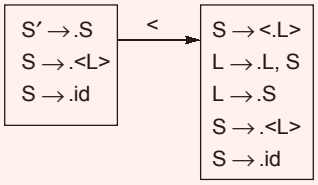
$S' \rightarrow S$

$S \rightarrow <L> \mid id$

$L \rightarrow L, S \mid S$

Let I_0 = CLOSURE ({[$S' \rightarrow S$]}). The number of items in the set GOTO (I_0, <) is _____.

Ans. (5)



Total number of items in the set GOTO (I_0, ⟨) is 5.

End of Solution

Q.27 Let the set of functional dependencies F = {QR → S, R → P, S → Q} hold on a relation schema X = (PQRS). X is not in BCNF. Suppose X is decomposed into two schemas Y and Z where Y = (PR) and Z = (QRS).

Consider the two statements given below:

I. Both Y and Z are in BCNF

II. Decomposition of X into Y and Z is dependency preserving and lossless

Which of the above statements is/are correct?

(a) I only (b) Neither I nor II

(c) Both I and II (d) II only

Ans. (d)

X(PQRS) {QR → S, R → P, S → Q} decomposed into

Y(PR)	Z(QRS)
{R → P}	{QR → S, S → Q}
Candidate key : R	Candidate key : QR, RS
Relation Y in BCNF	Relation Z in 3NF but not BCNF

Common attribute between Y and Z relations is R which is key for relation Y.

So that given decomposition is lossless join decomposition.

$R \rightarrow P$ in Y

$QR \rightarrow S$, $S \rightarrow Q$ } are in Z

and dependency preserving decomposition.

End of Solution

Q.28 Consider the following statements:

I. The smallest element in a max-heap is always at a leaf node.

II. The second largest element in a max-heap is always a child of the root node.

III. A max-heap can be constructed from a binary search tree in $\Theta(n)$ time.

IV. A binary search tree can be constructed from a max-heap in $\Theta(n)$ time.

Which of the above statements are TRUE?

(a) II, III and IV (b) I, II and III

(c) I, III and IV (d) I, II and IV

Ans. (b)

End of Solution

Q.29 Which one of the following languages over $\Sigma = \{a, b\}$ is NOT context-free?

(a) $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$ (b) $\{wa^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$

(c) $\{ww^R \mid w \in \{a, b\}^*\}$ (d) $\{wa^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$

Ans. (b)

(a) $\{a^n b^i \mid i \in \{n, 3n, 5n\}, n \geq 0\}$
$= a^n b^n \cup a^n b^{3n} \cup a^n b^{5n}$ is CFL since each of the three parts is a CFL and closure under union guarantees that result also is a CFL.

(b) $\{wa^n w^R b^n \mid w \in \{a, b\}^*, n \geq 0\}$ is a not CFL
because after pushing w, we need to push a's into stack which will stop the w from being matched with w^R. If we don't push a's after w, than later we cannot match with b^n. So this language is not acceptable by a PDA and hence not a CFL.

(c) $\{ww^R \mid w \in \{a, b\}^*\}$ is a CFL

(d) $\{wa^n b^n w^R \mid w \in \{a, b\}^*, n \geq 0\}$ is a CFL, since we can first push w, then a's, b's pop with a's and w^R pops with the w. So PDA can accept the language.

End of Solution

Q.30 Consider the following C function:

```
void convert (int n) {
    if (n < 0)
        printf("%d", n);
    else {
        convert (n/2);
        printf("%d", n % 2);
    }
}
```

Which one of the following will happen when the function convert is called with any positive integer *n* as argument?

(a) It will print the binary representation of *n* in the reverse order and terminate.
(b) It will print the binary representation of *n* but will not terminate.
(c) It will not print anything and will not terminate.
(d) It will print the binary representation of *n* and terminate.

Ans. (*)

End of Solution

Q.31 A relational database contains two tables Student and Performance as shown below:

Student

Roll_no.	Student_name
1	Amit
2	Priya
3	Vinit
4	Rohan
5	Smita

Performance

Roll_no.	Student_code	Marks
1	A	86
1	B	95
1	C	90
2	A	89
2	C	92
3	C	80

The primary key of the Student table is Roll_no. For the Performance table, the columns Roll_no. and Subject_code together from the primary key. Consider the SQL query given below:

```
SELECT S.Student_name, sum(P.Marks)
FROM Student S, Performance P
WHERE P.Marks > 84
GROUP BY S.Student_name;
```

The number of rows returned by the above SQL query is _____.

Ans. (5)

Student

Roll_no.	Student_name
1	Amit
2	Priya
3	Vinit
4	Rohan
5	Smita

×

Performance

Roll_no.	Student_code	Marks
1	A	86
1	B	95
1	C	90
2	A	89
2	C	92
3	C	80

In where condition no condition over Roll_no so query produces all groups. Total 5 different student names all 5 group records in result.

End of Solution

Q.32 Assume that in a certain computer, the virtual addresses are 64 bits long and the physical addresses are 48 bits long. The memory is word addressable. The page size is 8 kB and the word size is 4 bytes. The Translation Look-aside Buffer (TLB) in the address translation path has 128 valid entries. At most how many distinct virtual addresses can be translated without any TLB miss?

(a) 16×2^{10} (b) 8×2^{20}

(c) 4×2^{20} (d) 256×2^{10}

Ans. (d)

$$1 \text{ word} = 4 \text{ bytes}$$

$$\text{Page size} = 8 \text{ kB} = 2^{13} \text{ B}$$

$$\text{Number of words in 1 page} = \frac{2^{13}}{2^2} = 2^{11}$$

TLB can hold 128 valid entries so, at most 128×2^{11} memory address can be addressed without TLB miss.

$$128 \times 2^{11} = 256 \times 2^{10}$$

So option (d) is correct.

End of Solution

Q.33 Consider the following snapshot of a system running n concurrent processes. Process i is holding X_i instances of a resource R, $1 \le i \le n$. Assume that all instances of R are currently in use. Further, for all i, process i can place a request for at most Y_i additional instances of R while holding the X_i instances it already has. Of the n processes, there are exactly two processes p and q such that $Y_p = Y_q = 0$. Which one of the following conditions guarantees that no other process apart from p and q can complete execution?

(a) $X_p + X_q < \text{Min } \{Y_k \mid 1 \le k \le n, k \ne p, k \ne q\}$

(b) $\text{Min } (X_p, X_q) \ge \text{Min } \{Y_k \mid 1 \le k \le n, k \ne p, k \ne q\}$

(c) $\text{Min } (X_p, X_q) \le \text{Max } \{Y_k \mid 1 \le k \le n, k \ne p, k \ne q\}$

(d) $X_p + X_q < \text{Max } \{Y_k \mid 1 \le k \le n, k \ne p, k \ne q\}$

Ans. (a)

End of Solution

Q.34 Let G be any connected, weighted, undirected graph:

I. G has a unique minimum spanning tree, if no two edges of G have the same weight.

II. G has a unique minimum spanning tree, if for every cut G, there is a unique minimum weight edge crossing the cut.

Which of the above two statements is/are TRUE?

(a) Neither I nor II (b) I only

(c) II only (d) Both I and II

Ans. (d)

If no two edges of G have same weight surely G will have unique spanning tree is true. So I is true

Also if, for every cut of G, there is a unique minimum weight edge crossing the cut then G will have unique spanning tree is also true. So II is true

[**Note:** The converse of II is not true, but that is not relevant to this question]

So both I and II are true.

Option (d) is correct.

End of Solution

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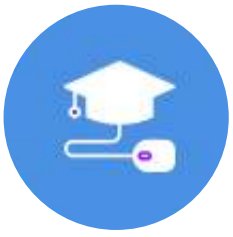

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Q.35 Consider the following matrix:

$$R = \begin{bmatrix} 1 & 2 & 4 & 8 \\ 1 & 3 & 9 & 27 \\ 1 & 4 & 16 & 64 \\ 1 & 5 & 25 & 125 \end{bmatrix}$$

The absolute value of the product of Eigen values of R is _____.

Ans. **(12)**

Product of eigen values is same as the determinant of a matrix.

$$\begin{bmatrix} 1 & 2 & 2^2 & 2^3 \\ 1 & 3 & 3^2 & 3^3 \\ 1 & 4 & 4^2 & 4^3 \\ 1 & 5 & 5^2 & 5^3 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 2^2 & 2^3 \\ 0 & 3-2 & 3^2-2^2 & 3^3-2^3 \\ 0 & 4-2 & 4^2-2^2 & 4^3-2^3 \\ 0 & 5-2 & 5^2-2^2 & 5^3-2^3 \end{bmatrix}$$

$$= (3-2)\,(4-2)\,(5-2) \begin{bmatrix} 1 & 5 & 19 \\ 1 & 6 & 28 \\ 1 & 7 & 39 \end{bmatrix}$$

$$= 1 \,.\, 2 \,.3 \begin{bmatrix} 1 & 5 & 19 \\ 0 & 1 & 9 \\ 0 & 2 & 20 \end{bmatrix}$$

$$= 1 \,.\, 2 \,.\, 3 \,.\, 2 = 12$$

So the product of eigen value is 12.

End of Solution

Q.36 In an RSA cryptosystem, the value of the public modulus parameter n is 3007. If it is also known that $\phi(n) = 2880$, where $\phi(\ )$ denotes Euler's Totient Function, then the prime factor of n which is greater than 50 is _____.

Ans. **(97)**

$$n = p \times q = 3007$$

$$\phi(n) = (p-1)\,(q-1) = 2880$$

Using RSA algorithm, $n = 31 \times 97$ in which 97 is prime factor which greater than 50. So 97 is correct answer.

End of Solution

Q.37 Consider the following relations P(X, Y. Z), Q(X, Y, T) and R(Y, V).

P		
X	Y	Z
X1	Y1	Z1
X1	Y1	Z2
X2	Y2	Z2
X2	Y4	Z4

Q		
X	Y	T
X2	Y1	2
X1	Y2	5
X1	Y1	6
X3	Y3	1

R	
Y	V
Y1	V1
Y3	V2
Y2	V3
Y2	V2

How many tuples will be returned by the following relational algebra query?

$\Pi_x(\sigma_{(P.Y = R.Y \wedge R.V = V2)}(P \times R)) - \Pi_x(\sigma_{(Q.Y = R.Y \wedge Q.T > 2)}(Q \times R))$

Ans. (1)

P

X	Y	Z
X1	Y1	Z1
X1	Y1	Z2
X2	Y2	Z2
X2	Y4	Z4

R

Y	V
Y1	V1
Y3	V2
Y2	V3
Y2	V2

$\Pi_x(\sigma_{(P.Y = R.Y \wedge R.V = V2)}(P \times R)) \Rightarrow$

X
X2

...(I)

Q

X	Y	T
X2	Y1	2
X1	Y2	5
X1	Y1	6
X3	Y3	1

R

Y	V
Y1	V1
Y3	V2
Y2	V3
Y2	V2

$\Pi_x(\sigma_{(Q.Y = R.Y \wedge Q.T > 2)}(Q \times R)) \Rightarrow$

X
X1

...(II)

I – II $\Rightarrow$

X
X2

one record in result.

End of Solution

Q.38 Consider the following C programs:

```
#include <stdio.h>
int main ( ) {
    float sum = 0.0, j = 1.0, i = 2.0;
    while (i/j > 0.0625) {
        j = j + j;
        sum = sum + i/j;
        printf("%f\n", sum);
    }
    return 0;
}
```

The number of times the variable sum will be printed, when the above program is executed, is _____.

Ans. (5)

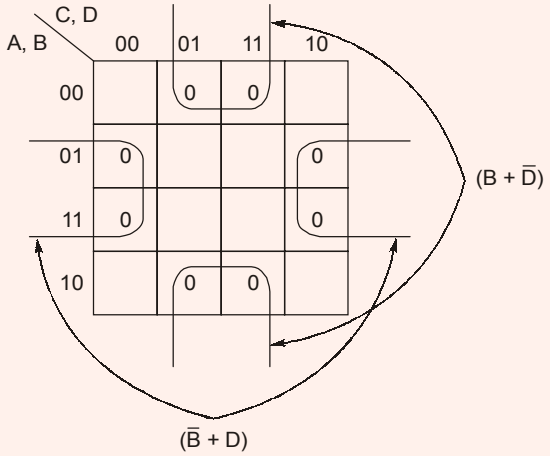
End of Solution

Q.39 What is the minimum number of 2-input NOR gates required to implement 4-variable function expressed in sum-of-minterms from as $f = \Sigma(0, 2, 5, 7, 8, 10, 13, 15)$? Assume that all the inputs and their complements are available _____.

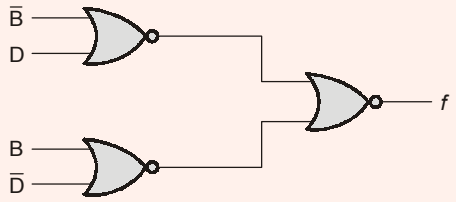
Ans. (3)

$f = \Sigma_m(0, 2, 5, 7, 8, 10, 13, 15)$

$f = \Pi_M(1, 3, 4, 6, 9, 11, 12, 14)$



$f = (\bar{B}+D)(B+\bar{D})$



So 3 NOR gates is required.

End of Solution

Q.40 Consider the following sets:

S_1 : Set of all recursively enumerable languages over the alphabet {0, 1}.

S_2 : Set of all syntactically valid C programs.

S_3 : Set of all languages over the alphabet {0, 1}.

S_4 : Set of all non-regular languages over the alphabet {0, 1}.

Which of the above sets are uncountable?

(a) S_1 and S_2 (b) S_3 and S_4

(c) S_1 and S_4 (d) S_2 and S_3

Ans. (b)

S_1 : The set L_{RE} is known to be countably infinite since it corresponds with set of turing machines.

S_2 : Since syntactically valid C programs surely run on Turing machines, this set is also a subset of set of Turing machines, which is countable.

S_3 : Set of all languages = 2^{Σ^*} which is known to be uncountable. Σ^* countably infinite $\Rightarrow 2^{\Sigma^*}$ is uncountable.

S_4 : Set of all non-regular languages includes set $L_{NOT\ RE}$ which is uncountable infinite and hence is uncountable.

So, S_3 and S_4 are uncountable.

End of Solution

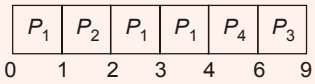
Q.41 Consider the following four processes with arrival times (in milliseconds) and their length of CPU burst (in milliseconds) as shown below:

Process	P_1	P_2	P_3	P_4
Arrival time	0	1	3	4
CPU time	3	1	3	Z

These processes are run on a single processor using preemptive Shortest Remaining Time First scheduling algorithm. If the average waiting time of the processes is 1 millisecond, then the value of Z is _____.

Ans. (2)

Assume, $Z = 2$



	Arrival time	CPU time	Completion time	Waiting time
P_1	0	3	4	1
P_2	1	1	2	0
P_3	3	3	9	3
P_4	4	$Z = 2$	6	0

Average waiting time (WT) = $\frac{1+0+3+0}{4} = 1\text{ms}$

Hence, $Z = 2$

End of Solution

Q.42 Consider the following C program:

```
#include<stdio.h>
int r( )
{
    Static int num = 7;
    return num --;
}
int main( )
{
    for ( r( ); r( ); r( ) )
        printf("%d",r( ) );
    return 0;
}
```

Which one of the following values will be displayed on execution of the programs?

(a) 41 (b) 630

(c) 63 (d) 52

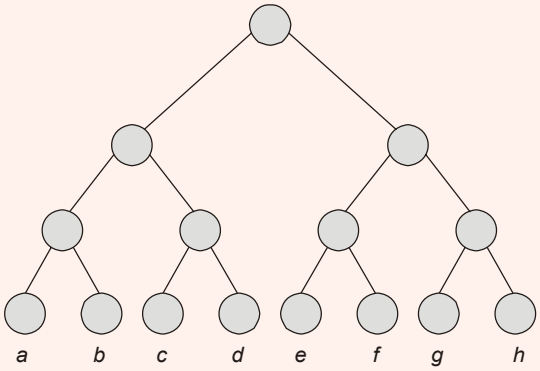
Ans. (d)

End of Solution

Q.43 Let T be a full binary tree with 8 leaves. (A full binary tree has every level full.) Suppose two leaves *a* and *b* of T are chosen uniformly and independently at random. The expected value of the distance between *a* and *b* in T (i.e., the number of edges in the unique path between *a* and *b*) is (rounded off to 2 decimal places) _____.

Ans. **(4.85) (4.85 to 4.86)**

Two nodes can be selected in ${}^{8}C_{2} = 28$ ways.



X : length between two nodes selected

X	2	4	6
$P(x)$	$\frac{4}{28}$	$\frac{8}{28}$	$\frac{16}{28}$

To find expected length between *a* and *b* is E[X]

$$E[X] = 2\left(\frac{4}{28}\right)+4\left(\frac{8}{28}\right)+6\left(\frac{16}{28}\right)$$

$$= \frac{8+32+96}{28} = \frac{136}{28} = 4.857$$

End of Solution

Q.44 Consider the first order predicate formula:

$\forall x[(\forall z\ z \mid x \Rightarrow ((z = x) \vee (z = 1))) \Rightarrow \exists w\ (w > x) \wedge (\forall z\ z \mid w \Rightarrow ((w = z) \vee (z = 1)))]$

Here '$a \mid b$' denotes that 'a divides b', where a and b are integers. Consider the following sets:

S_1: {1, 2, 3, ..., 100}

S_2: Set of all positive integers

S_3: Set of all integers

Which of the above sets satisfy φ?

(a) S_1 and S_3 (b) S_2 and S_3

(c) S_1, S_2 and S_3 (d) S_1 and S_2

Ans. **(b)**

$\forall x[\forall z \mid x \Rightarrow ((z = x) \vee (z = 1)) \Rightarrow \exists w\ (w > x) \wedge (\forall z\ z \mid w \Rightarrow ((w = z) \vee (z = 1)))]$

The predicate φ simply says that if z is a prime number in the set then there exists another prime number is the set which is larger.

Clearly φ is true in S_2 and S_3 since in set of all integers as well as all positive integers, there is a prime number greater than any given prime number.

However, in S_1 : {1, 2, 3, ...100} φ is false since for prime number 97 $\in S_1$ there exists no prime number in the set which is greater.

End of Solution

Q.45 Suppose Y is distributed uniformly in the open interval (1,6). The probability that the polynomial $3x^2 + 6xY + 3Y + 6$ has only real roots is (rounded off to 1 decimal place) _____.

Ans. **(0.8)**

Polynomial $3x^2 + 6xY + 3Y + 6$ has only real roots

$$b^2 - 4ax \geq 0$$

$$(6Y)^2 - 4(3)(3Y + 6) \geq 0$$

$$Y^2 - Y + 2 \geq 0$$

$Y \in (-\infty, -1] \cap [2, \infty)$

$\Rightarrow Y \in [2, 6)$

Since y is uniformly distributed in (1, 6)

Probability distributed function

$$f(Y) = \frac{1}{5} \quad 1 < y < 6$$

$$p(2 \leq y < 6) = \int_2^6 f(Y)\,dy$$

$$= \frac{1}{5}[Y]_2^6 = \frac{4}{5} = 0.8$$

End of Solution

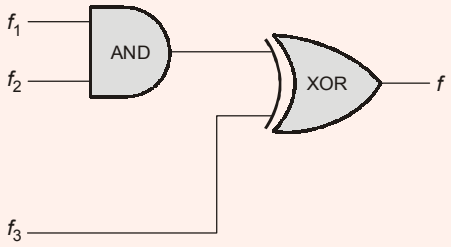
Q.46 Consider three 4-variable functions f_1, f_2 and f_3, which are expressed in sum-of-minterms as

$f_1 = \Sigma(0, 2, 5, 8, 14)$

$f_2 = \Sigma(2, 3, 6, 8, 14, 15)$

$f_3 = \Sigma(2, 7, 11, 14)$

For the following circuit with one AND gate and one XOR gate, the output function f can be expressed as:



(a) $\Sigma(7, 8, 11)$ (b) $\Sigma(2, 14)$

(c) $\Sigma(0, 2, 3, 5, 6, 7, 8, 11, 14, 15)$ (d) $\Sigma(2, 7, 8, 11, 14)$

Ans. (a)

$$f_1 \cdot f_2 = \Sigma(2, 8, 14)$$
$$f_1 = f_3 \oplus (f_1 \cdot f_2)$$
$$= \Sigma(7, 8, 11)$$

End of Solution

Q.47 Consider the following grammar and the semantic actions to support the inherited type declaration attributes. Let X_1, X_2, X_3, X_4, X_5 and X_6 be the place holders for the non-terminals D, T, L or L_1 in the following table:

Productions rule	Semantic action
$D \rightarrow TL$	X_1.type = X_2.type
$T \rightarrow$ int	T.type = int
$T \rightarrow$ float	T.type = float
$L \rightarrow L_1$, id	X_3.type = X_4.type addType(id.entry, X_5.type)
$L \rightarrow$ id	addType(id.entry, X_6.type)

Which one of the following are the appropriate choices for X_1, X_2, X_3 and X_4?

(a) $X_1 = L, X_2 = T, X_3 = L_1, X_4 = L$ (b) $X_1 = L, X_2 = L, X_3 = L_1, X_4 = T$

(c) $X_1 = T, X_2 = L, X_3 = L_1, X_4 = T$ (d) $X_1 = T, X_2 = L, X_3 = T, X_4 = L_1$

Ans. (a)

SDT for inserting type information in the symbol table

$D \rightarrow TL$ {L.idtype = T.stype}

$T \rightarrow$ int {T.stype = int}

$T \rightarrow$ float {T.stype = float}

$L \rightarrow L_1$, id {L_1.itype = L.itype}

addtype(id.entry, L.itype)

$L \rightarrow$ id addtype(id.entry, L.itype)

Replace these attribute information in the given SDT.

So option (a) is the correct answer.

End of Solution

Q.48 Consider three machines M, N and P with IP addresses 100.10.5.2, 100.10.5.5 and 100.10.5.6 respectively. The subnet mask is set to 255.255.255.252 for all the three machines. Which one of the following is true?

(a) M, N and P all belong to the same subnet

(b) Only N and P belong to the same subnet

(c) M, N, and P belong to three different subnets

(d) Only M and N belong to the same subnet

Ans. (b)

M →	100.10.5.2	2	00000010
	255.255.255.252	252	11111100
	194.56.10.0	0	00000000
N →	100.10.5.5	5	00000101
	255.255.255.252	252	11111100
	194.56.10.4	4	00000100
P →	100.10.5.6	6	00000110
	255.255.255.252	252	11111100
	194.56.10.4	4	00000100

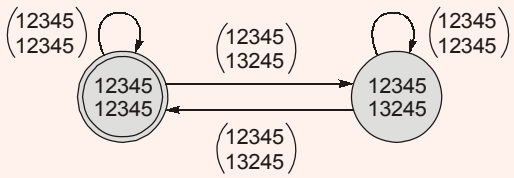
N and P belongs to same subnet.

End of Solution

Q.49 Let Σ be the set of all bijections from {1, ..., 5} to {1, ..., 5}, where id denotes the identity function, i.e. id(j) = j, $\forall j$. Let $\circ$ denote composition on functions.
For a string $x = x_1\ x_2 \ldots x_n \in \Sigma^n$, $n \geq 0$, let $\pi(x) = x_1 \circ x_2 \circ \ldots \circ x_n$.
Consider the language $L = \{x \in \Sigma^* \mid \pi(x) = \text{id}\}$. The minimum number of states in any DFA accepting L is _____.

Ans. (120)

The DFA for accepting L will have 5! = 120 states, since we need one state for every possible permutation function on 5 elements. The starting state will be "id" state, named as $\begin{pmatrix}12345\\12345\end{pmatrix}$ and from there $n!$ arrows will go the $n!$ states each named with a distinct permutation of the set {1, 2, 3, 4, 5}. Since composition of permutation function is closed every arrow has to go to some permutation and hence some state.
Since the language only has those strings where $\pi(x)$ = id only the starting state ("id" state) will be the final state. Sample machine with only 2 states is shown below



End of Solution

Q.50 A certain processor deploys a single-level cache. The cache block size is 8 words and the word size is 4 bytes. The memory system uses a 60 MHz clock. To service a cache miss, the memory controller first takes 1 cycle to accept the starting address of the block, it then takes 3 cycles to fetch all the eight words of the block, and finally transmits the words of the requested block at the rate of 1 word per cycle. The maximum bandwidth for the memory system when the program running on the processor issues a series of read operations is _____ $\times 10^6$ bytes/sec.

Ans. (160)

Total time to transfer a cache block = 1 + 3 + 8 = 12 cycles
8 W ——— 12 cycles
8 × 4 bytes ——— 12 cycles
? B ——— 1 sec

$$= \frac{32B}{12\times\left(\frac{1}{60}+10^{-6}\right)\text{sec}}$$

$$= 160 \times 10^6 \text{ bytes/sec}$$

End of Solution

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ADMISSION OPEN

Q.51 There are n unsorted arrays: A_1, A_2, ..., A_n. Assume that n is odd. Each of A_1, A_2, ..., A_n contains n distinct elements. There are no common elements between any two arrays. The worst-case time complexity of computing the median of the medians of A_1, A_2, ..., A_n is

(a) $O(n \log n)$
(b) $O(n^2)$
(c) $O(n)$
(d) $\Omega(n^2 \log n)$

Ans. (b)

End of Solution

Q.52 Consider that 15 machines need to be connected in a LAN using 8-port Ethernet switches. Assume that these switches do not have any separate uplink ports. The minimum number of switches needed is _____.

Ans. (3)

3 switches of ethernet are required to connect 15 computers.

End of Solution

Q.53 The index node (inode) of a Unix-like file system has 12 direct, one single-indirect and one double-indirect pointers The disk block size is 4 kB and the disk block address is 32-bits long. The maximum possible file size is (rounded off to 1 decimal place) _____ GB.

Ans. (4.0)

End of Solution

Q.54 Suppose that in an IP-over-Ethernet network, a machine X wishes to find the MAC address of another machine Y in its subnet. Which one of the following techniques can be used for this?

(a) X sends an ARP request packet with broadcast IP address in its local subnet
(b) X sends an ARP request packet to the local gateway's MAC address which then finds the MAC address of Y and sends to X
(c) X sends an ARP request packet with broadcast MAC address in its local subnet
(d) X sends an ARP request packet to the local gateway's IP address which then finds the MAC address of Y and sends to X

Ans. (c)

End of Solution

Q.55 Consider the following C program:

```
#include <stdio.h>
int main ( )
{
    int a[ ] = {2, 4, 6, 8, 10};
    int i, sum = 0, *b = a + 4;
    for (i = 0; i < 5; i++)
        sum = sum + (*b – i) – *(b – i);
    printf ("%d\n", sum);
    return 0;
}
```

The output of the above C program is _____.

Ans. (10)

End of Solution

■■■■