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GATE - 2021

Questions with Detailed Solutions

COMPUTER SCIENCE & INFORMATION TECHNOLOGY

(Forenoon Session)

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GATE - 2021

Question with Detailed Solutions

08/02/21

Morning Session

COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

SUBJECTWISE WEIGHTAGE

S. No.	NAME OF THE SUBJECT	Number of Questions
01	Discrete Mathematics	12
02	Theory Computation	5
03	Compiler Design	4
04	Database Management Systems	5
05	Computer Networks	4
06	Operating Systems	4
07	Algorithms	8
08	Data Structures	3
09	Programming Languages	2
10	Digital Logic	2
11	Computer Organization & Architecture	6
12	Verbal Ability	3
13	Numerical Ability	7
Total No. of Questions		65

Section : General Aptitude

01.

Items	Cost(₹)	Profit%	Marked Price (₹)
P	5.400	---	5.860
Q	---	25	10.000

Details of prices of two items P and Q are presented in the above table. The ratio of cost of item P to cost of item Q is 3:4. Discount is calculated as the difference between the marked price and the selling price. The profit percentage is calculated as the ratio of the difference between selling price and cost, to the cost

(Profit % = $\frac{\text{Selling price} - \text{Cost}}{\text{Cost}} \times 100$)

The discount on item Q. as a percentage of its marked price, is _____

(a) 25 (b) 10

(c) 12.5 (d) 5

01. Ans: (b)

Sol: Cost of Q (Cq) = (4/3) * Cp = 7200

Let Selling price of Q = S

25 = (S – 7200)*100 / 7200

S = 9000

Discount on S = 10000 – 9000 = 1000

Discount on S i.e. 1000 is 10% of marked price of Q i.e. 10,000.

So, answer is 10.

02. Given below are two statements 1 and 2, and two conclusions I and II.

Statement 1: All bacteria are microorganisms

Statement 2: All pathogens are microorganisms

Conclusion I: Some pathogens are bacteria

Conclusion II: All pathogens are not bacteria

Based on the above statements and conclusions. Which one of the following options is logically CORRECT?

(a) Only conclusion II is correct

(b) Either conclusion I or II is correct

(c) Neither conclusion I nor II is correct

(d) Only conclusion I is correct

02. Ans: (b)

Sol: Whatever situation we have, either conclusion I or conclusion II will be true.

If conclusion I is false then II will be true and vice versa. So, either conclusion I or conclusion II will be true.

03. There are five bags each containing identical sets of ten distinct chocolates. One chocolate is picked from each bag.

The probability that at least two chocolates are identical is _____

(a) 0.6976 (b) 0.3024

(c) 0.8125 (d) 0.4235

03. Ans: (a)

Sol: Probability that all the picked chocolates are distinct

= (10*9*8*7*6) / 10^5 = 0.3024

Probability that at least two of the picked chocolates are identical

=1 – (Probability that all the picked chocolates are distinct)

= 1– 0.3024 = 0.6976

04. Consider the following sentences:

(i) Everybody in the class is prepared for the exam.

(ii) Babu invited Danish to his home because he enjoys playing chess

Which of the following is the CORRECT observation about the above two sentences?

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(a) (i) is grammatically incorrect and (ii) is unambiguous
(b) (i) is grammatically correct and (ii) is unambiguous
(c) (i) is grammatically correct and (ii) is ambiguous
(d) (i) is grammatically incorrect and (ii) is ambiguous

04. Ans: (c)

Sol: Everybody is prepared means they are ready for the exam, The second sentence does not clearly state whether Babu will play with Danish or not. Babu loves playing chess the doesn't means Danish knows how to play chess.

05. The ratio of boys to girls in a class is 7 to 3
Among the options below, an acceptable value for the total number of students in the class is:
(a) 21 (b) 73 (c) 37 (d) 50

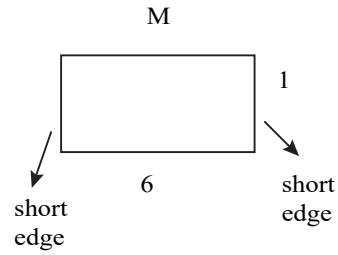
05. Ans: (d)

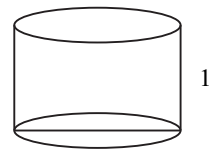
Sol: Let number of boys = B
Let total number of students = S
So, we have
$B / (S-B) = 7/3$
$B = 7S / 10$
So, S must be multiple of 10. Hence, answer is 50

06. We have 2 rectangular sheets of paper. M and N, of dimensions 6 cm × 1 cm each. Sheet M is rolled to form an open cylinder by bringing the short edges of the sheet together. Sheet N is cut into equal square patches and assembled to form the largest possible closed cube. Assuming the ends of the cylinder are closed, the ratio of the volume of the cylinder to that of the cube is_____
(a) 3π (b) $\frac{9}{\pi}$
(c) $\frac{3}{\pi}$ (d) $\frac{\pi}{2}$

06. Ans: (b)

Sol:





Circumference of lower circle $2\pi r = 6$

$r = \frac{\cancel{6}^{3}}{\cancel{2}\pi} = \frac{3}{\pi}$

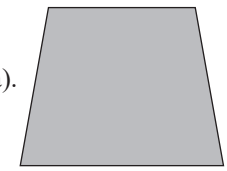
Volume of cylinder $= \pi r^2 h$

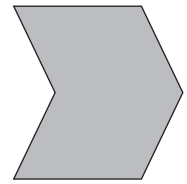
$= \pi\left(\frac{3}{\pi}\right)^2 (1)$

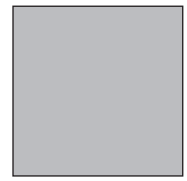
$V_1 = \frac{9}{\pi}$

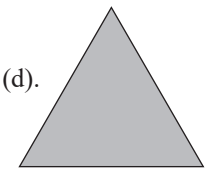
Volume of cube $a^3 = (1)^3$ ∴ a = side of cube = 1

07. A polygon is convex if, for every pair of points, P and Q belonging to the polygon, the line segment PQ lies completely inside or on the polygon.
Which one of the following is NOT a convex polygon?

(a). 

(b). 

(c). 

(d). 

07. Ans: (b)

Sol:

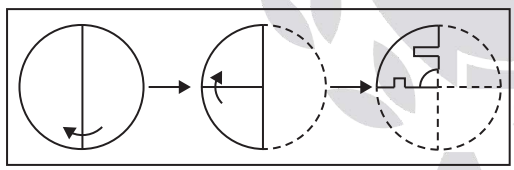
If we choose two points P, Q such that P is the top-left corner and Q is the bottom left corner then the line joining P,Q will not lie on the polygon.

08. _____ is to surgery as writer is to_____
Which one of the following options maintains a similar logical relation in the above sentence?
(a) Doctor, book
(b) Plan, outline
(c) Medicine, grammar
(d) Hospital, library

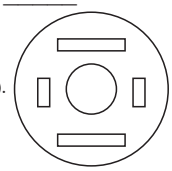
08. Ans: (a)

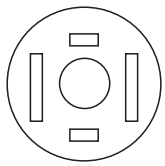
Sol: A doctor performs surgery just as a writer writes a book. (Person and skill)

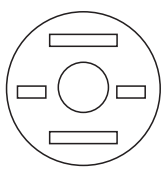
09.

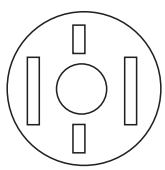


A circular sheet of paper is folded along the lines in the directions shown. The paper, after being punched in the final folded state as shown and unfolded in the reverse order of folding, will look like_____

(a). 

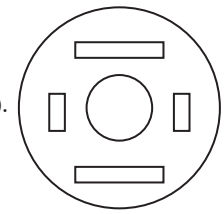
(b). 

(c). 

(d). 

09. Ans: (a)

Sol:

(a). 

10. Some people suggest anti-obesity measures (AOM) such as displaying calorie information in restaurant menus. Such measures sidestep addressing the core problems that cause obesity: poverty and income inequality
Which one of the following statements summarizes the passage?
(a) AOM are addressing the core problems and are likely to succeed
(b) If obesity reduces, poverty will naturally reduce, since obesity causes poverty
(c) The proposed AOM addresses the core problems that cause obesity
(d) AOM are addressing the problem superficially

10. Ans: (d)

Sol: Some people have displayed information in restaurant menus about to AOM. However, menus have sidestepped addressing the problems superficially. Superficial means shallow, cursory mean lacking in depth or solidity. superficial implies a concern only with surface aspects or obvious features. A superficial analysis of the problem shallow is more generally derogatory in implying lack of depth in knowledge, reasoning, emotions, or character.

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Section : Computer Science & Information Technology

01. Let G be a group of order 6 and H be a subgroup of G such that $1 < |H| < 6$.
(a) Both G and H are always cyclic
(b) G is always cyclic, but H may not be cyclic
(c) G may not be cyclic, but H is always cyclic
(d) Both G and H may not be cyclic

01. Ans: (c)

Sol: For any element g in any group G, one can form the subgroup of all integer powers $\square g \square = \{g^k \mid k \square Z\}$, called the cyclic subgroup of g.
The order of g is the number of elements in $\square g \square$; that is, the order of an element is equal to the order of its cyclic subgroup.
A cyclic group is a group which is equal to one of its cyclic subgroups: $G = \square g \square$ for some element g, called a generator.
(Lagrange's theorem) Let G be a finite group and H $\square$ G a subgroup of G. Then |H| divides |G|.
We know that If G is a finite group with |G| prime, then G is cyclic.

Proof :

Let $p = |G|$. Since $p \geq 2$, there is an element $g \square G$ with g e. Consider the subgroup $\langle g \rangle \square G$ generated by g. We have $|\langle g \rangle| \geq 2$ since both e, $g \square \langle g \rangle$. So by Lagrange's theorem $|\langle g \rangle| = p$. Thus $\langle g \rangle = G$, and so, by definition, G is cyclic as claimed.
Classification of Groups of Order $n \leq 3$:
n=1: The trivial group <e> is the only group with 1 element.
n=2,3 : These orders are prime, so Lagrange implies that any such group is cyclic.
Given that G has order 6, and H is subgroup of G so, H has order either 1 or 2 or 3 or 6 But it is given that $1 < |H| < 6$, So, order of H could be either 2 or 3, so H is cyclic.
A group of order 6 may or may not be cyclic.

02. The following relation records the age of 500 employees of a company, where empNo (indicating the employee number) is the key:

emp Age(empNo, age)

Consider the following relational algebra expression:

$\Pi_{empNo}(empAge \bowtie_{(age>age1)} \rho_{empNo\ 1,\ age1}(emp\ Age))$

What does the above expression generate?
(a) Employee numbers of only those employees whose age is the maximum
(b) Employee numbers of only those employees whose age is more than the age of exactly one other employee
(c) Employee numbers of all employees whose age is the minimum
(d) Employee numbers of all employees whose age is not the minimum

02. Ans: (d)

Sol:

empAge	
empon	age
1	20
2	19
3	18

empAge	
empno1	age1
1	20
2	19
3	18

The query return

empno
1
2

$\therefore$ The query returns Employee number of all employers whose age is not the minimum.

03. Assume that a 12-bit Hamming codeword consisting of 8-bit data and 4 check bits is $d_8 d_7 d_6 d_5 c_8 d_4 d_4 d_3 d_2 c_4 d_1 c_2 c_1$, where the data bits and the check bits are given in the following tables:

Data bits							
d_8	d_7	d_6	d_5	d_4	d_3	d_2	d_1
1	1	0	x	0	1	0	1

Check bits			
c_8	c_4	c_2	c_1
y	0	1	0

Which one of the following choices gives the correct values of x and y?

(a) x is 0 and y is 0

(b) x is 1 and y is 1

(c) x is 1 and y is 0

(d) x is 0 and y is 1

03. Ans: (a)

Sol: $\underline{D_{12}\ D_{11}\ D_{10}\ D_9\ P_8\ D_7\ D_6\ D_5\ P_4\ D_3\ P_2\ P_1}$

1 1 0 x y 0 1 0 0 1 1 0

$P_1 = 0 + 1 + 0 + 0 + x + 1;\ x = 0$ even

$P_2 = 1 + 1 + 1 + 0 + 0 + 1 =$ even

$P_4 = 0 + 0 + 1 + 0 + 1$ even

$P_8 = y + x + 0 + 1 + 1 = 0$

x = 0 and

y = 0

04. Consider the following instruction sequence where registers R1, R2 and R3 are general purpose and MEMORY[X] denotes the content at the memory location X.

Instruction	Semantics	Instruction size(bytes)
MOV R1, (5000)	R1←MEMORY[5000]	4
MOV R2, (R3)	R2 ←MRMORY [R3]	4
ADD R2, R1	R2← R1 + R2	2
MOV (R3), R2	MEMORY[R3]←R2	4
INC R3	R3← R3+1	2
DEC R1	R1← R1–1	2
BNZ 1004	Branch if not zero to the given absolute address	2
HALT	Stop	1

Assume that the content of the memory location 5000 is 10 and the content of the register R3 is 3000. The content of each of the memory locations from 3000 to 3010 is 50. The instruction sequence starts from the memory location 1000. All the numbers are in decimal format. Assume that the memory is byte addressable.

After the execution of the program, the content of memory location 3010 is _____

04. Ans: 50

Sol: Memory type is Byte addressable

1000: $MOVR_1$, (5000)

1004: $MOVR_2$, (R_3)

1008: ADD R_2, R_1

1010: MOV (K_3), R_2

1014: INC R_3

1016: DEC R_1

1018: JNZ 1004

1020: HLT

Since the initial content of 3010 is 50 and program is executed for ten times, the content of memory location from 3000 to 3009 are changed from 60 to 51, but there is no change in the content of 3010; Hence Answer: 50.

05. An articulation point in a connected graph is a vertex such that removing the vertex and its incident edges disconnects the graph into two or more connected components.

Let T be a DFS tree obtained by doing DFS in a connected undirected graph G.

Which of the following options is/are correct?

(a) Root of T can never be an articulation point in G

(b) If u is an articulation point in G such that x is an ancestor of u in T and y is a descendant of u in T, then all paths from x to y in G must pass through u.

(c) A leaf of T can be an articulation point in G

(d) Root of T is an articulation point in G if and only if it has 2 or more children.

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05. Ans: (d)

06. Consider the following array

23	32	45	69	72	73	89	97

Which algorithm out of the following options uses the least number of comparisons (among the array elements) to sort the above array in ascending order?

(a) Insertion sort
(b) Merge sort
(c) Selection sort
(d) Quick sort using the last element as pivot

06. Ans: (a)

Sol: The given array is already sorted in ascending order. For already sorted array :

Selection sort :

No matter how the data is arranged there would always be comparisons and swaps made and so the time complexity for best,average and worst case is : $O(n^2)$.

In first pass, we need n–1 comparisons (Or n comparisons, depending on the implementation)
In second pass, we need n–2 comparisons (Or n–1 comparisons, depending on the implementation) and so on..
So, The number of comparisons required by a selection sort of n items can be computed by the formula:

$(n-1) + (n-2) + \ldots + 1 = (n)(n-1)/2$
Or
Number of selection sort comparisons= $(n+1)(n)/2$
Basically, number of comparisons are $\Theta(n^2)$ in all cases.

Insertion Sort :

When elements are sorted, there are no swaps and the correct position of the element in the sorted list is the current index itself. The time complexity is : O(n)
Number of comparisons = n − 1
Comparisons in total: $1+1 + \ldots + 1 = n - 1 \in \Theta(n)$.

Merge Sort :

We are dividing the list into two no matter if the list is sorted or no. But if the array is sorted, while merging the list there are no swaps merging results into an array itself. Thus, the best, average and worst case time complexity is: O(nlogn)
Number of comparisons, in all cases, will be O(nlogn)

Quick Sort :

The best case is when the elements are in a sorted manner. The best and average case time complexity is : O(nlogn)
Number of comparisons, in best case, will be O(nlogn)
So, answer will be insertion sort. So, answer is option a.

07. For a Turing machine M, <M> denotes an encoding of M. Consider the following two languages.

L_1 = {<M> | M takes more than 2021 steps on all inputs}
L_2 = {<M> | M takes more than 2021 steps on some inputs}

Which one of the following options is correct?

(a) Both L_1 and L_2 are undecidable
(b) Both L_1 and L_2 are decidable
(c) L_1 is decidable and L_2 is undecidable
(d) L_1 is undecidable and L_2 is decidable

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07. Ans: (b)

Sol: $L_1 = \{< m >\} \mid M$ takes more then 2021 steps on all inputs$\}$

$L_2\{< m > \mid M\}$ takes more than 2021 steps on some inputs$\}$

construct the TM M_1 for L_1

Start the TM M_1 for all the inputs and wait up to 2021 steps.

At step of 2021, the machine decides

it requires more than 2021 steps or NOT.

$\therefore$ We have an algorithm to decide about L_1

$\Rightarrow L_1$ is decidable.

Similarly construct the TM M_2 for the language L_2.

Start the TM M_2 and wait up to 2021 steps for inputs of L_2. If M_2 takes more than 2021 steps for some of the strings L_2 then L_2 is decidable

$\Rightarrow L_2$ is also decidable

08. Consider the following matrix

$$\begin{pmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{pmatrix}$$

The largest eigenvalue of the above matrix is ____

08. Ans: 3

Sol:

. $|A - \lambda I| = \begin{vmatrix} -\lambda & 1 & 1 & 1 \\ 1 & -\lambda & 1 & 1 \\ 1 & 1 & -\lambda & 1 \\ 1 & 1 & 1 & -\lambda \end{vmatrix} = 0$

$\Rightarrow R_1 \to R_1 + R_2 + R_3 + R_4$

$$\begin{vmatrix} -\lambda+3 & -\lambda+3 & -\lambda+3 & -\lambda+3 \\ 1 & -\lambda & 1 & 1 \\ 1 & 1 & -\lambda & 1 \\ 1 & 1 & 1 & -\lambda \end{vmatrix} = 0$$

$C_2 \to C_2 - C_1,\ C_3 \to C_3 - C_1,\ C_4 \to C_4 - C_1$

$$\begin{vmatrix} -\lambda+3 & 0 & 0 & 0 \\ 1 & -\lambda-1 & 0 & 0 \\ 1 & 0 & -\lambda-1 & 0 \\ 1 & 0 & 0 & -\lambda-1 \end{vmatrix} = 0$$

$(-\lambda + 3)(-\lambda - 1)^3 = 0$

$\lambda = 3$ is the largest eigen values

09. There are 6 jobs with distinct difficulty levels, and 3 computers with distinct processing speeds. Each job is assigned to a computer such that:

- The fastest computer gets the toughest job and the slowest computer gets the easiest job
- Every computer gets atleast one job

The number of ways in which this can be done is ____

09. Ans: 65

Sol: Let jobs be J1 to J6, where J1 is toughest. Let computers be C1,C2,C3 where C1 is the fastest.

So, J1 goes to C1, J6 goes to C3.

Remaining 4 jobs can go to any computer, But computer C2 must get at least one job.

So, Total Cases when Remaining 4 jobs can go to any computer = 34

Cases when computer C2 is Not assigned any job = 24

Cases when every computer gets at least one job = 81 – 16 = 65

10. Let the representation of a number in base 3 be 210. What is the hexadecimal representation of the number?

(a) 528 (b) 21 (c) 15 (d) D2

10. Ans: (c)

Sol: $(210)_3 = (?)_{10}$

$2 \quad 1 \quad 0 = 18 + 3 = 21_{10}$

$3^2 \quad 3^1 \quad 3^0$

$21_{10} = 15_{16}$

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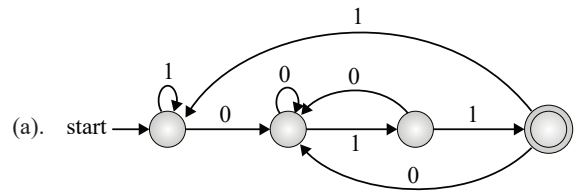
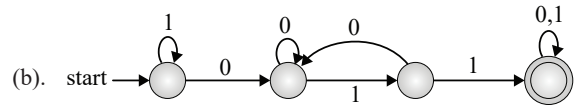
11. A relation R is said to be circular if aRb and bRc together imply cRa.
Which of the following options is/are correct?
(a) If a relation S is reflexive and circular, then S is an equivalence relation
(b) If a relation S is circular and symmetric, then S is an equivalence relation
(c) If a relation S is reflexive and symmetric, the S is an equivalence relation
(d) If a relation S is transitive and circular, then S is an equivalence relation

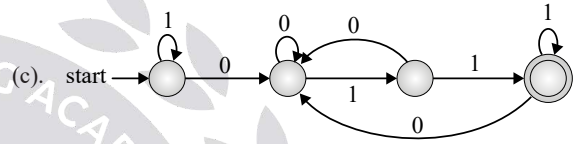
11. Ans: (a)

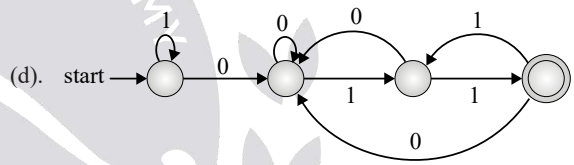
Sol: If R is reflexive and circular then it is symmetric because assume aRb. Then since R is reflexive, we have bRb. Since R is circular, so, aRb, bRb will mean that we have bRa, so, R is symmetric.
If R is reflexive and circular then it is transitive because assume aRb, bRc. Since R is circular, so, cRa, and since R is symmetric so aRc so R is transitive.
So, option A is correct.
Option B is false. For counter example, take a set A = {a,b,c}, define relation R on A as follows : R = { (a,a) }, R is symmetric and circular but not equivalence relation.
Option C is false. For counter example, take a set A = {a,b,c}, define relation R on A as follows : R = { (a,a), (b,b),(c,c), (a,b),(b,a), (a,c),(c,a) }, R is symmetric and reflexive but not transitive so not equivalence relation.
Option D is false. For counter example, take a set A = {a,b,c}, define relation R on A as follows : R = { (a,a) }, R is transitive and circular but not equivalence relation.

12. Consider the following language
L = {w ∈ {0, 1}* | w ends with the substring 011}
Which one of the following deterministic finite automata accepts L?

(a). 

(b). 

(c). 

(d). 

12. Ans: (a)

Sol: Option b is false because it is accepting 01111.
Option c is false because it is accepting 01111.
Option d is false because it is accepting 01111.

13. Consider the following ANSI C function:

```
int SimpleFunction(int Y[], int n, int x)
{
    int total = Y[0], loopIndex;
    for (loopIndex = 1; loopIndex <= n–1;
    loopIndex++)
        total = x * total + Y[loopIndex];
    return total;
}
```

Let Z be an array of 10 elements with Z[i] = 1, for all i such that 0 ≤ i ≤ 9. The value returned by Simple function (Z, 10, 2) is _____

13. Ans: 1023

Sol: Initially,

total = 1

for (Index =1; Index< = n–1;Index++)

total = 2* total + Y[Index];

→This forms a series of terms like:

$a_0 = 1$

$a_1 = 2* a_0 + 1 = 3$

$a_2 = 2* a_1 + 1 = 7$

.

.

.

$a_n = 2* a_8 + 1$

$\therefore a_n = 2* a_{n-1} + 1$

$\boxed{\therefore a_n = 2 * a_{n-1} + 1}$

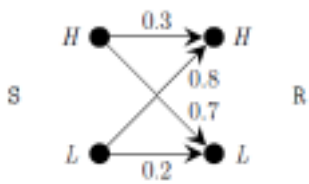
The series:

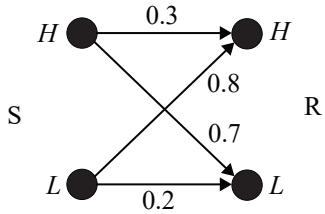
3, 7, 15, 31, 63, 127, 255, 511, 1023

$\boxed{\therefore \text{Total} = a_9 = 1023}$

14. A sender (S) transmits a signal, which can be one of the two kinds: H and L with probabilities 0.1 and 0.9 respectively, to a receiver (R).

In the graph below, the weight of edge (u, v) is the probability of receiving v when u is transmitted, where u, v ∈{H, L}. For example, the probability that the received signal is L given the transmitted signal was H, is 0.7

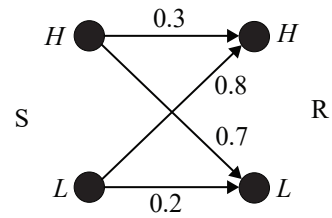




If the received signal is H, the probability that the transmitted signal was H (rounded to 2 decimal places) is _____

14. Ans: 0.04

Sol:



$$P(TH \mid RH) = \frac{p(TH \cap RH)}{P(RH)} \rightarrow (1)$$

$$P(RH) = P(TH)\,P(RH \mid TH) + P(TL)\,P(RH \mid TL)$$
$$= 0.1 \times 0.3 + 0.9 \times 0.8$$
$$= 0.03 + 0.72$$
$$= 0.75$$

$$P(TH \cap RH) = P(TH)\,P(RH \mid TH)$$
$$= 0.1 \times 0.3$$
$$= 0.03$$

$$(1) \Rightarrow P(TH \mid RH) = = \frac{0.03}{0.75} = 0.04$$

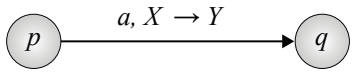
15. Which of the following standard C library functions will always invoke a system call when executed from a single -threaded process in a UNIX/Linux operating system?

(a) sleep (b) malloc

(c) strlen (d) exit

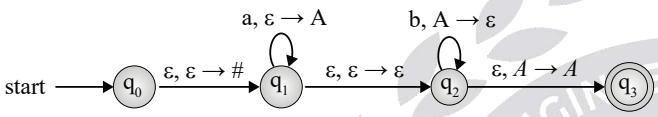
15. Ans: (a) & (d)

16. In a pushdown automation P = {Q, Σ, Γ,δ, Q_0, F), a transition of the form,



where p, q ∈,Q a ∈ Σ ∪ {ε} and X, Y ∈Γ∪ {ε}, represents (q, Y) ∈δ (p, α,X)

Consider the following pushdown automaton over the input alphabet Σ={a, b} and stack alphabet Γ= {#, A}



The number of strings of length 100 accepted by the above pushdown automaton is _____

16. Ans: 50

Sol: The given PDA can accept the strings of the language L = $\{a^k \mid k \geq 1\}$i.e any string which has contain one or more number of a's.

Another language of the PDA L = $\{a^m a^n \mid m > n\}$ i.e. only number of a's followed any no. of b's with condition a's should be greater than no. of b's

Therefore the language L can be drawn as

$L = \{a^k \mid K \geq 1\} \cup \{a^m b^n \mid m > n\}$

Let us see possible string that can accepted by PDA

Let

n = 2	n = 4	n = 6	n = 100
1 aa	1. aaaa	1. aaaaaa	willbe
only (1)	2. aaab	2. aaaaaa	$\frac{100}{2} = 50$
Ans: $\frac{2}{1} = 1$	only (2)	3. aaaabb	
	$\Rightarrow \frac{4}{2} =$	only (3)	

$\Rightarrow \frac{6}{2} = (3)$

if n = 100 then possible strings are $\frac{100}{2} = 50$.

17. Consider the following grammar (that admits a series of declarations, followed by expressions) and the associated syntax directed translation (SDT) actions, given as pseudo-code:

P → D* E*

D → int ID {record that ID.lexeme is of type int}

D → boo1 ID {record that ID. lexeme is of type boo1}

$E \rightarrow E_1 + E_2$ {check that E_1 type = E_2. type = int; set E. type: = int}

$E \rightarrow !E_1$ {check that E_1. type = boo1; set E. type : = boo1}

E → ID {set E. type := int}

With respect to the above grammar, which one of the following choices is correct?

(a) The actions will lead to an infinite loop

(b) The actions can be used to type-check syntactically correct boolean variable declarations and boolean expressions

(c) The actions can be used to type-check syntactically correct integer variable declarations and integer expressions

(d) The actions can be used to correctly type-check any syntactically correct program

17. Ans: (c)

Sol: The grammar deriving only integer variables but not boolean variables. So options a, b and d are ruled out.

18. A binary search tree T contains n distinct elements. What is the time complexity of picking an element in T that is smaller than the maximum element in T?

(a) Θ(1) (b) Θ(log n)

(c) Θ(n log n) (d) Θ(n)

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18. Ans: (a)

Sol: If our data structure contains n distinct elements then :

In all the standard data structures that we know/ study about, If we want to pick/find an element which is Not maximum (smaller than maximum) then time complexity will be because we only need to compare any two elements. Take any two elements that you can access in constant time, compare them and return smaller of those two elements.

PS :By "standard data structures that we know/ study about" I mean the following :

Binary tree, Binary search tree, AVL tree, sorted or unsorted array, linked lists, arrays, stacks, queues, hash tables, heaps etc.

19. Let $r_i(z)$ and $w_i(z)$ denote read and write operations respectively on a data item z by a transaction T_i. Consider the following two schedules.

S_1: $r_1(x)\ r_1(y)\ r_2(x)\ r_2(y)\ w_2(y)\ w_1(x)$

S_2: $r_1(x)\ r_2(x)\ r_2(y)\ w_2(y)\ r_1(y)\ w_1(x)$

Which one of the following options is correct?

(a) Both S_1 and S_2 are conflict serializable

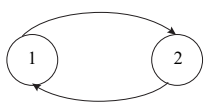
(b) S_1 is not conflict serializable and S_2 is conflict serializable

(c) S_1 is conflict serializable and S_2 is not conflict serializable

(d) Neither S_1 nor S_2 is conflict serializable

19. Ans: (b)

Sol: Precedence graph of S_1.



Precedence graph of S_2

Graph of S_1 contains cycles and S_2 contains no-cycles

$\therefore$ S_1 is not c.s and S_2 is c.s

20. Consider the following recurrence relation

$$T(n) = \begin{cases} T(n/2) + T(2n/5) + 7n & \text{if } n > 0 \\ 1 & \text{if } n = 0 \end{cases}$$

Which one of the following options is correct?

(a) $T(n) = \Theta(n \log n)$

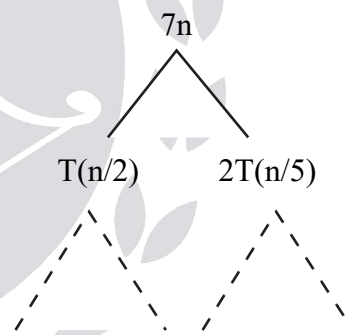
(b) $T(n) = \Theta((\log n)^{5/2})$

(c) $T(n) = \Theta(n^{5/2})$

(d) $T(n) = \Theta(n)$

20. Ans: (d)

Sol: With recursion tree approach the cost at every level is proportional to n.



21. Consider the following pseudocode, where S is a semaphore initialized to 5 in line#2 and counter is a shared variable initialized to 0 in line# 1. Assume that the increment operation in line # 7 is not atomic

```
1. int counter = 0
2. Semaphore S = init(5);
3. void parop(void)
4. {
5.      wait (S);
6.      wait (S);
7.      counter++;
8.      signal (S);
9.      signal (S);
10. }
```

If five threads execute the function parop concurrently, which of the following program behavior(s) is/are possible?

(a) There is a deadlock involving all the threads

(b) The value of counter is 5 after all the threads successfully complete the execution of parop

(c) The value of counter is 1 after all the threads successfully complete the execution of parop

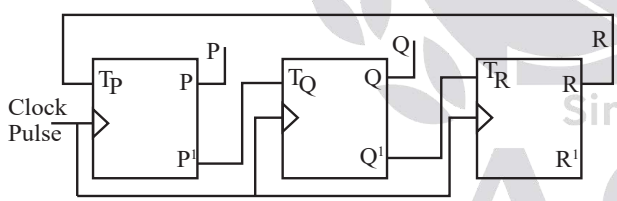
(d) The value of counter is 0 after all the threads successfully complete the execution of parop

21. Ans: (a), (b) & (c)

Sol: Deadlock is possible if all processes involve the first wait (s) & get pre-empted.

Final value can be 5 when all processes execute without pre-emptions. Final value can never be zero, as atleast one process can execute the increment operation with proper termination.

22. Consider a 3-bit counter, designed using T flip-flops, as shown below:



Assuming the initial state of the counter given by PQR as 000, what are the next three states?

(a) 011, 101, 111 (b) 001, 010, 000

(c) 011, 101, 000 (d) 001, 010, 111

22. Ans: (c)

Sol: From the circuit, given

$T_P = R$; $T_Q = \overline{P}$; $T_R = \overline{Q}$

Initially PQR = 000;

For T flip flop $\Rightarrow$

T	Q_{n+1}
0	Q_n
1	$\overline{Q_n}$

Clock	T_P	T_Q	T_R	P	Q	R
0	-	-	-	0	0	0
1	0	1	1	0	1	1
2	1	1	0	1	0	1
3	1	0	1	0	0	0

Next three states are 011, 101, 000

23. Let <M> denote an encoding of an automaton M. Suppose that $\Sigma = \{0, 1\}$. Which of the following languages is/are NOT recursive?

(a) $L = \{<M> \mid M \text{ is a DFA such that } L(M) = \phi\}$

(b) $L = \{<M> \mid M \text{ is a PDA such that } L(M) = \phi\}$

(c) $L = \{<M> \mid M \text{ is a DFA such that } L(M) = \Sigma^*\}$

(d) $L = \{<M> \mid M \text{ is a PDA such that } L(M) = \Sigma^*\}$

23. Ans: (d)

Sol: (a) $L = \{<M> \mid M \text{ is a DFA such that } L[M] = \phi\}$

$\Rightarrow$ emptiness of DFA is $\frac{\text{decidable}}{\text{recursive}}$

(b) $L = \{<M> \mid M \text{ is a PDA such that } L(M) = \phi\}$

$\Rightarrow$ emptiness of PDA is also $\frac{\text{decidable}}{\text{Recursive}}$

(c) $L = \{\ m \mid M \text{ is DFA such that } L(M) = \Sigma^*\}$

$\Rightarrow$ Universal ness of DFA is $\frac{\text{decidable}}{\text{Recursive}}$

(d) $L = \{\ M \mid M \text{ is PDA such that } L(M) = \Sigma^*\}$

Acceptance of Σ^* by PDA is $\frac{\text{undecidable}}{\text{NA Recursive}}$

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24. Consider two hosts P and Q connected through a router R. The maximum transfer unit (MTU) value of the link between P and R is 1500 bytes and between R and Q is 820 bytes

A TCP segment of size 1400 bytes was transferred from P to Q through R, with IP identification value as 0x1234. Assume that the IP header size is 20 bytes. Further, the packet is allowed to be fragmented, i.e., Don't Fragment (DF) flag in the IP header is not set by P.

Which of the following statements is/are correct?

(a) If the second fragment is lost, P is required to resend the whole TCP segment

(b) TCP destination port can be determined by analyzing only the second fragment

(c) If the second fragment is lost, R will resend the fragment with the IP identification value 0x1234

(d) Two fragments are created at R and the IP datagram size carrying the second fragment is 620 bytes

24. Ans: (a) & (d)

Sol: Reason (d) : At router , 1400 bytes are transmitted into two packets(payload of 800+600)as follows: first datagram = IP header 20 bytes + payload of 800bytes(100elementary fragments size of 8bytes)
= 820 bytes

Second packet = IP header 20 bytes + payload of 600bytes(75 elementary fragments size of 8bytes)
= 620 bytes

25. Consider the sliding window flow-control protocol operating between a sender and a receiver over a full-duplex error-free link. Assume the following:
The time taken for processing the data frame by the receiver is negligible

- The time taken for processing the acknowledgment frame by the sender is negligible
- The sender has infinite number of frames available for transmission
- The size of the data frame is 2,000 bits and the size of the acknowledgment frame is 10 bits
- The link data rate in each direction is 1 Mbps ($=10^6$ bits per second)
- One way propagation delay of the link is 100 milliseconds.

The minimum value of the sender's window size in terms of the number of frames, (rounded to the nearest integer) needed to achieve a link utilization of 50% is _____

25. Ans: 50

Sol: Transmission delay = 2 msec, Ack Transmission delay = 0.01 msec, propagation delay = 100 msec
0.5 = W * 2 / 2 + 200 + 0.01
W=202.01/4=50.5025
So, Window size = 50

26. Consider the following context-free grammar where the set of terminals is{a, b, c, d, f}

S→d a T | Rf
T → a S| baT|ε
R →caTR| ε

The following is a partially-filled LL(1) parsing table

	a	b	c	d	f	$
S			①	S→daT	②	
T	T→aS	T→baT	③		T→ ε	④
R			R→caTR		R→ ε	

Which one of the following choices represents the correct combination for the numbered cells in the parsing table ("blank" denotes that the corresponding cell is empty)?

(a) ① S → Rf ② blank ③ blank ④ T→ε
(b) ① blank ② S →Rf ③ blank ④ blank
(c) ① blank ② S →Rf ③ T→ε ④ T→ε
(d) ① S →Rf ② S →Rf ③ T→ε ④ T→ε

26. Ans: (d)

Sol: S → Rf is to be placed in M[S, first (Rf)] that is

$m[S, c] = S \rightarrow Rf$

$m[S, f] = S \rightarrow Rf$

T→ε is to be placed in m [T, follow (T)]

that is $M[T, \$] T \rightarrow \varepsilon$

$m[T, C] = T \rightarrow \varepsilon.$

27. A relation r (A, B) in a relational database has 1200 tuples. The attribute A has integer values ranging from 6 to 20, and the attribute B has integer values ranging from 1 to 20. Assume that the attributes A and B are independently distributed.
The estimated number of tuples in the output of $\sigma_{(A>10)\vee(B=18)}$ (r) is _____

27. Ans: 820

Sol: Probability (A > 10) = $\frac{10}{15}$

Probability (B = 18) = $\frac{1}{20}$

Probability (A > 10 and B = 18) = $\frac{10}{15} \times \frac{1}{20}$

(Because both are independent events)

Probability (A > 10 or B = 18)

= Probability(A>10)+Probability(B=18)

– Probability(A > 10 and B = 18)

$= \frac{10}{15} + \frac{1}{20} - \frac{1}{30}$

$= \frac{40 + 3 - 2}{60} = \frac{41}{60}$

The estimated number of tuples

$= 1200 \times \frac{41}{60} = 820$

28. Consider the following representation of a number in IEEE 754 single-precision floating point format with a bias of 127.
S : 1 E: 10000001 F: 11110000000000000000
Here S, E and F denote the sign, exponent and fraction components of the floating point representation.
The decimal value corresponding to the above representation (rounded to 2 decimal places) is ____

28. Ans: –7.75

Sol: S = 1, E = 10000001,

F = m = 111100 ....0 (23)

$E = 1000000\ 1_1 = 129$

128

$\therefore e = 129 - 127 = 2$

Since S= 1, data sign is negative

expression value $(-1)^s \times 1.m \times 2^e$

$(-1)^1 \times 1.1111000 ...0 \times 2^2$

$(-)111.11_2$

$= (1)1\ \ 1\ \ 1.\ 1\ \ 1$

$2^2\ \ 2^1\ 2^0\ 2^{-1}\ 2^{-2}$

(–)7.75

29. Suppose that L_1 is a regular language and L_2 is a context-free language. Which one of the following languages in NOT necessarily context-free?
(a) $L_1 \cap L_2$ (b) $L_1 \cup L_2$
(c) $L_1 - L_2$ (b) $L_1 . L_2$

29. Ans: (c)

Sol: L_1 is a regular language

L_2 is a context free language

then $L_1 \leq L_2$

$\Rightarrow L_1 \cap L_2$ is a context free

$\Rightarrow L_1 \cup L_2$ is a context free

$\Rightarrow L_1, L_2$ is a context free

but $L_1 - L_2 = L_1 \cap \overline{L_2}$ is not context free

Since $\overline{L_2}$ is not context free.

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30. Consider the following expression

$$\lim_{x\to -3}\frac{\sqrt{2x+22}-4}{x+3}$$

The value of the above expression (rounded to 2 decimal places) is _____

30. Ans: 0.25

Sol:

$$\lim_{x\to -3}\frac{\sqrt{2x+22}-4}{x+3}\left(\frac{0}{0}\right)$$

Applying L'Hospital rule

$$=\lim_{x\to -3}\frac{2}{2\sqrt{2x+22}}$$

$$=\frac{1}{\sqrt{2(-3)+22}}$$

$$=\frac{1}{\sqrt{16}}$$

$$=\frac{1}{4}$$

$$=0.25$$

31. Suppose a database system crashes again while recovering from a previous crash. Assume check pointing is not done by the database either during the transactions or during recovery.
Which of the following statements is/are correct?
(a) The system cannot recover any further
(b) All the transactions that are already undone and redone will not be recovered again
(c) The same undo and redo list will be used while recovering again
(d) The database will become inconsistent

31. Ans: (c)

Sol: In order to recover the database even on multiple crashes the same undo and redo list will used.

32. Consider the following statements.
S_1: Every SLR(1) grammar is unambiguous but there are certain unambiguous grammars that are not SLR(1)
S_2: For any context-free grammar, there is a parser that takes at most $O(n^3)$ time to parse a string of length n.
Which one of the following options is correct?
(a) S_1 is true and S_2 is true
(b) S_2 is false and S_2 is false
(c) S_1 is false and S_3 is true
(d) S_1 is true and S_2 is false

32. Ans: (a)

Sol: Every SLR (1) grammar is unambiguous, but every unambiguous grammar need not be SLR(1).
For any CFG, there is a parser that takes atmost $O(n^3)$ time to parse a string of length 'n'

33. Consider the following statements
S_1: The sequence of procedure calls corresponds to a preorder traversal of the activation tree
S_2: The sequence of procedure returns corresponds to a postorder
Which one of the following options is correct?

(a) S_1 is false and S_2 is false
(b) S_1 is true and S_2 is false
(c) S_1 is false and S_2 is true
(d) S_1 is true and S_2 is true

33. Ans: (d)

Sol: We can make the following observations about these procedure calls.
1. If an activation of p calls q, then that activation of p terminates no earlier than the activation of q.
2. The order of activations (procedure calls) corresponds to a preorder traversal of the call tree.

3. The order of de-activations (procedure returns) corresponds to postorder traversal of the call tree.
4. If execution is currently in an activation corresponding to a node N of the activation tree, then the activations that are currently live are those corresponding to N and its ancestors in the tree.
5. These live activations were called in the order given by the root-to-N path in the tree, and the returns will occur in the reverse order.

The use of a run-time stack is enabled by several useful relationships between the activation tree and the behavior of the program:

1. The sequence of procedure calls corresponds to a preorder traversal of the activation tree.
2. The sequence of returns corresponds to a postorder traversal of the activation tree.
3. Suppose that control lies within a particular activation of some procedure, corresponding to a node N of the activation tree. Then the activations that are currently open (live) are those that correspond to node N and its ancestors. The order in which these activations were called is the order in which they appear along the path to N , starting at the root, and they will return in the reverse of that order.

34. Consider the following sequence of operations on an empty stack

push (54); push (52); pop(); push(55); push(62); s = pop();

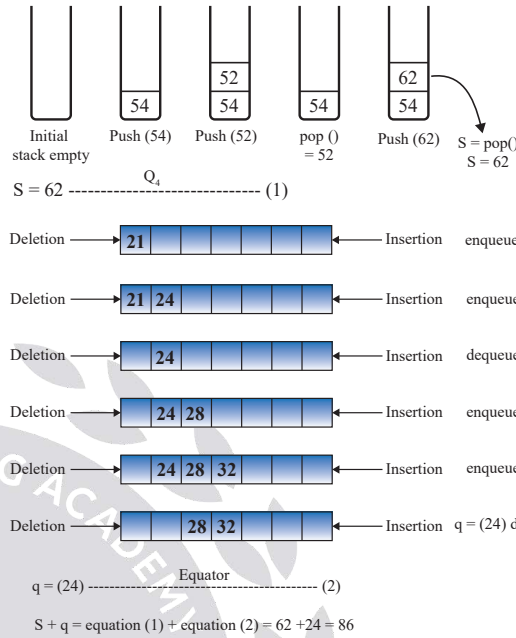
Consider the following sequence of operations on an empty queue

enqueue(21); enqueue(24); dequeue(); enqueue(28); enqueue(32); q = dequeue();

The value of s+q is____

34. Ans: 86

Sol:



35. Consider a linear list based directory implementation in a file system. Each directory is a list of nodes, where each node contains the file name along with the file metadata, such as the list of pointers to the data blocks. Consider a given directory foo.

Which of the following operations will necessarily require a full scan of foo for successful completion?

(a) Opening of an existing file in foo
(b) Creation of a new file in foo
(c) Renaming of an existing file in foo
(d) Deletion of an existing file from foo

35. Ans: (b), (c)

Sol: Options (b) & (c) would require to traverse the directly foo fully. The other two operations does not require.

36. Let G = (V, E) be an undirected unweighted connected graph. The diameter of G is defined as:

$\text{diam}(G) = \max_{u,v \in V} \{\text{the length of shortest path between u and v}\}$

Let M be the adjacency matrix of G.

Define graph G_2 on the same set of vertices with adjacency matrix N, where

$$N_{ij} = \begin{cases} 1 & \text{if } M_{ij} > 0 \text{ or } P_{ij} > 0, \text{ where } P = M^2 \\ 0 & \text{otherwise} \end{cases}$$

Which one of the following statements is true?

(a) $\lceil \text{diam}(G)/2 \rceil < \text{diam}(G_2) < \text{diam}(G)$

(b) $\text{diam}(G_2) \le \lceil \text{diam}(G)/2 \rceil$

(c) $\text{diam}(G_2) = \text{diam}(G)$

(d) $\text{diam}(G) < \text{diam}(G_2) \le 2\,\text{diam}(G)$

36. Ans: (b)

Sol: If M is an adjacency matrix of G then M^2 represents all paths of length 2;

in general, M^L represents all paths of length L, for $L \ge 1$.

On undirected graph, when we do $M^2 + M$, we get G2 in which all the edges of G are already there, additionally we have edges between those vertices of G which have a path of length less than or equal to 2 between them.

So, Diam(G2) will be half the diam(G), option B is correct.

37. In an undirected connected planar graph G, there are eight vertices and five faces. The number of edges in G is _____

37. Ans: 11

Sol: Let G be a planar, connected graph. Let V be the number of vertices, E the number of edges, and F the number of faces in G. Then V−E+F=2.

By euler formula for connected planar graph,

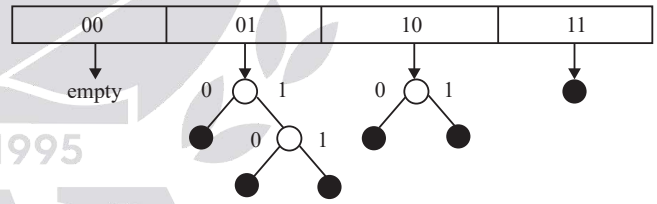
f = e−v+2

So, e =11

38. Consider a dynamic hashing approach for 4-bit integer keys:

1. There is a main hash table of size 4
2. The 2 least significant bits of a key is used to index into the main hash table
3. Initially, the main hash table entires are empty
4. Thereafter, when more keys are hashed into it, to resolve collisions, the set of all keys corresponding to a main hash table entries is organized as a binary tree that grows on demand
5. First, the 3rd least significant bit is used to divide the keys into left and right subtrees
6. To resolve more collisions, each node of the binary tree is further sub-divided into left and right subtrees based on the 4th least significant bit
7. A split is done only if it is needed, i.e., only when there is a collision.

Consider the following state of the hash table



Which of the following sequences of key insertions can cause the above state of the hash table (assume the keys are in decimal notation)?

(a) 5, 9, 4, 13, 10, 7

(b) 9, 5, 10, 6, 7, 1

(c) 10, 9, 6, 7, 5, 13

(d) 9, 5, 13, 6, 10, 14

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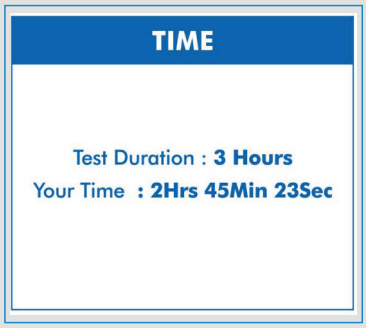

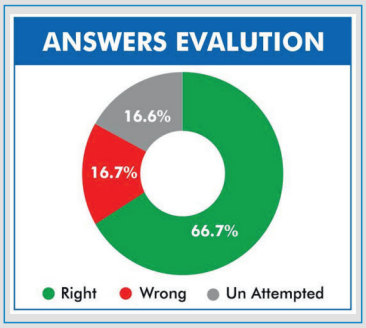

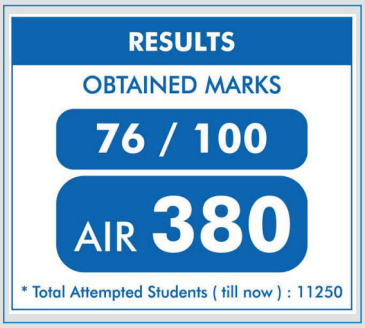

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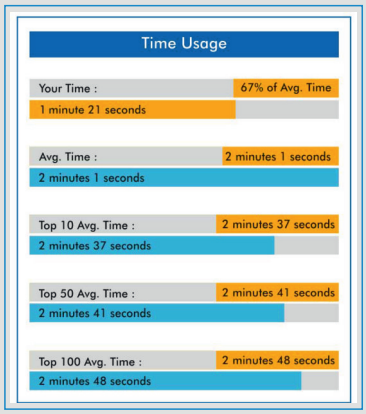

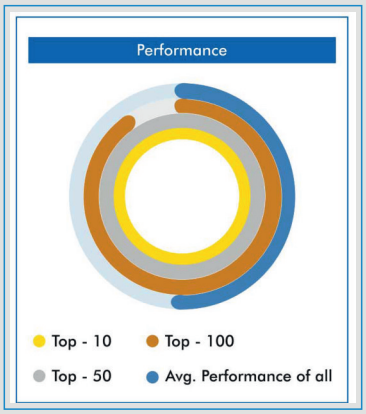

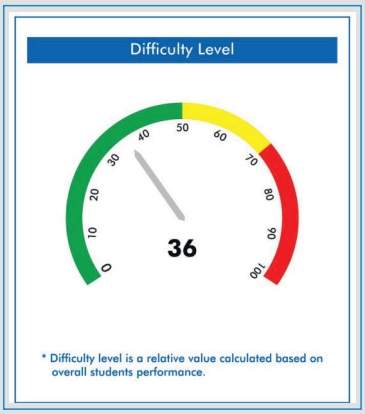

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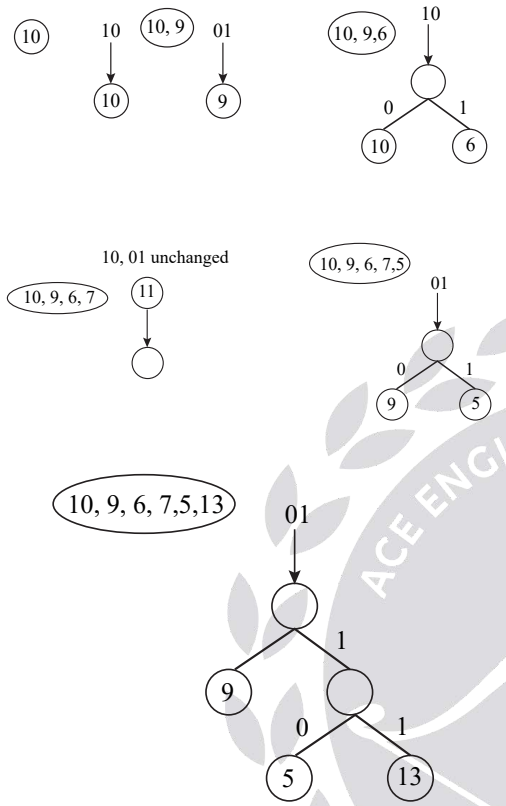
38. Ans: (c)

Sol: (c) 10, 9, 6, 7, 5, 13



39. Consider the following three functions

$f_1 = 10^n, f_2 = n^{\log n}, f_3 = n^{\sqrt{n}}$

Which one of the following options arranges the functions in the increasing order of asymptotic growth rate?

(a) f_1, f_2, f_3 (b) f_3, f_2, f_1

(c) f_2, f_3, f_1 (d) f_2, f_1, f_3

39. Ans: (c)

Sol: $f_1 = 10^n$; $f_2 = n^{\log n}$; $f_3 = n^{\sqrt{n}}$

take log of all

n.log10 logn. logn $\sqrt{n}$. logn

n. c $(\log n)^2$ $\sqrt{n}$. logn

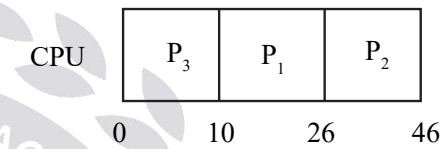
since $\sqrt{n}$ is greater than log n

$\therefore (\log n)^2 < \sqrt{n} \log n < c.n$ $(f_2 < f_3 < f_1)$

40. Three processes arrive at time zero with CPU bursts of 16, 20 and 10 milliseconds. If the scheduler has prior knowledge about the length of the CPU bursts, the minimum achievable average waiting time for these three processes in a non-preemptive scheduler (rounded to nearest integer) is _____milliseconds.

40. Ans: 12

Sol: Gantt chart



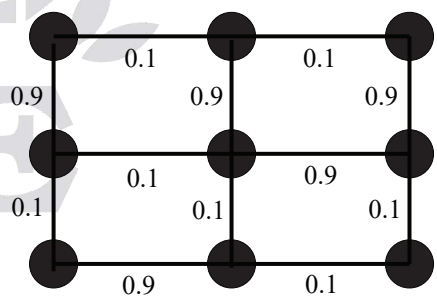
W. $T(P_1) = 10$

W.$T(P_2) = 26$

$WT(P_3) = \frac{0}{36}$

$\frac{36}{3} = 12$

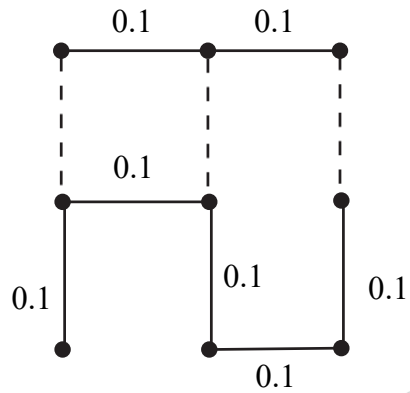
41. Consider the following undirected graph with edge weights as shown



The number of minimum-weight spanning trees of the graph is _____

41. Ans: 3

Sol:



Out of the three parallel edges with wt. of 0.9, one can be taken in $^3c_1$ ways

$\therefore$ 3 MCSTs are possible

42. A TCP server application is programmed to listen on port number P on host S. A TCP client is connected to the TCP server over the network.

Consider that while the TCP connection was active, the server machine S crashed and rebooted. Assume that the client does not use the TCP keepalive timer. Which of the following behaviours is/are possible?

(a) The TCP server application on S can listen on P after reboot

(b) If the client sends a packet after the server reboot, it will receive FIN segment

(c) If the client was waiting to receive a packet, it may wait indefinitely.

(d) If the client sends a packet after the server reboot, it will receive a RST segment.

42. Ans: (a), (c) and (d)

Sol: After server reboots, it doesn't have any information of previous connection, so, client may have to wait indefinitely as client doesn't have keep alive timer.

Also, as a general rule, reset (RST) must be sent whenever a segment arrives which apparently is not intended for the current connection.

Since, the previous connection got terminated, now server can again listen on P.

43. The lifetime of a component of a certain type is a random variable whose probability density function is exponentially distributed with parameter 2. For a randomly picked component of this type, the probability that its lifetime exceeds the expected lifetime(rounded to 2 decimal places) is ____.

43. Ans: 0.3678

Sol: $\lambda=2$

$f(x) = 2\,e^{-2x}$, $x \geq 0$

$= 0$, elsewhere

Let X = life time of a component

$P(x>E(x)) = P\left(x > \frac{1}{\lambda}\right)$

$= P\left(x > \frac{1}{2}\right)$

$= \int_{\frac{1}{2}}^{\infty} f(x)\,dx$

$= \int_{\frac{1}{2}}^{\infty} 2\,e^{-2x}\,dx$

$= 2\left\{\frac{-e^{-2x}}{2}\right\}_{\frac{1}{2}}^{\infty}$

$= (-e^{-\infty}) - \left(-e^{-2\left(\frac{1}{2}\right)}\right)$

$=0 + e^{-1} = \frac{1}{e} = 0.3678.$

44. Consider the following two statements.

S_1: Destination MAC address of an ARP reply is a broadcast address.

S_2: Destination MAC address of an ARP request is a broadcast address.

Which one of the following choices is correct?

(a) S_1 is false and S_2 is true

(b) Both S_1 and S_2 are false

(c) S_1 is true and S_2 is false

(d) Both S_1 and S_2 are true

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44. Ans: (a)

Sol: Address Resolution Protocol

If a machine talks to another machine in the same network, it requires its physical or MAC address. But ,since the application has given the destination's IP address it requires some mechanism to bind the IP address with its MAC address. This is done through Address Resolution protocol (ARP). IP address of the destination node is broadcast and the destination node informs the source of its MAC address.

1. Assume broadcast nature of LAN
2. Broadcast IP address of the destination
3. Destination replies it with its MAC address.
4. Source maintains a cache of IP and MAC address bindings

There are four types of arp messages that may be sent by the arp protocol. These are identified by four values in the "operation" field of an arp message. The types of message are:

1. ARP-Request (Broadcast, source IP address of the requester)
2. ARP-Reply (Unicast to requester, the target)

45. Let p and q be two propositions. Consider the following two formula in propositional logic

S_1: $(\neg p \wedge (p \vee q)) \rightarrow q$

S_2: $q \rightarrow (\neg p \wedge (p \vee q))$

Which one of the following choices is correct?

(a) Neither S_1 nor S_2 is a tautology

(b) S_1 is tautology but S_2 is not a tautology

(c) Both S_1 and S_2 are tautologies

(d) S_1 is not a tautology but S_2 is a tautology

45. Ans: (b)

Sol: S_1, S_2 are implication statements. Implication statement $X \rightarrow Y$ is tautology if and only if it can never happen that "X is true and Y is false" simultaneously.

S_1 :

$(\neg p \wedge (p \vee q)) \rightarrow q$

Here, $Y = q$, $X = (\neg p \wedge (p \vee q))$

When $Y = q$ is false, then $X = (\neg p \wedge (p \vee q))$ cannot become true, so S_1 is tautology.

S_2 :

$q \rightarrow (p \wedge (p \vee q))$

Here, $X = q$, $Y = (\neg p \wedge (p \vee q))$

When $X = q$ is true, still $Y = (\neg p \wedge (p \vee q))$ can become false, so, S_2 is not a tautology.

46. Consider the following Boolean expression

$F = (X+Y+Z)\ (\overline{X}+Y)\ (\overline{Y}+Z)$

Which of the following Boolean expressions is/are equivalent to $\overline{F}$ (complement of F)?

(a) $X\overline{Y}+Y\overline{Z}+\overline{X}\ \overline{Y}\ \overline{Z}$

(b) $(X+\overline{Z})\ (\overline{Y}+\overline{Z})$

(c) $(\overline{X}+\overline{Y}+\overline{Z})(X+\overline{Y})(Y+\overline{Z})$

(d) $X\overline{Y}+\overline{Z}$

46. Ans: (a), (b) & (d)

Sol: Given $F = \underset{\text{term1}}{(x+y+z)}\ \underset{\text{term2}}{(\overline{x}+y)}\ \underset{\text{term3}}{(\overline{y}+z)}$

From term1 $\Rightarrow$ x y z

0 0 0 $\Rightarrow M_0$

From term2 $\Rightarrow$ 1 0 x $\rightarrow M_4, M_5$

From term3 $\Rightarrow$ x 1 0 $\rightarrow M_2, M_6$

[Notes Here "x" means don't care}

$F = \pi M[0,2,4,5,6] = \sum m[1,3,7]$

↓ Absent terms ↓ Absent terms

$\overline{F} = \pi M[1,3,7] = \sum m[0,2,4,5,6]$

Complement of

$F = \overline{F} = \sum m(0,2,4,5,6) = \Pi M(1,3,7)$

Now verify options

Option (a): $x\bar{y} + y\bar{z} + \bar{x}\,\bar{y}\,\bar{z}$

	x	y	z	
From term 1 $\Rightarrow$	1	0	x	$\rightarrow m_4, m_5$
from terms 2 $\Rightarrow$	x	1	0	$\rightarrow m_2, m_3$
From terms 3 $\Rightarrow$	0	0	0	$\Rightarrow m_0$

$\sum m[0, 2, 4, 5, 6]$ hence True

Option b: $(x + \bar{z})(\bar{y} + \bar{z})$

	x	y	z	
From term 1 $\Rightarrow$	0	x	1	$\Rightarrow M_4, M_3$
From term 2 $\Rightarrow$	x	1	1	$\rightarrow M_3, M_7$

$\Rightarrow \Pi M[1, 3, 7] = \sum m[0, 2, 4, 5, 6]$

Hence option (b) is also True.

Option c: $(\bar{x} + \bar{y} + \bar{z})(x + \bar{y})(y + \bar{z})$

	x	y	z	
From term 1 $\Rightarrow$	1	1	1	$\rightarrow M_7$
From term2 $\Rightarrow$	0	1	x	$\rightarrow M_2, M_3$
From term3 $\Rightarrow$	x	0	1	$\rightarrow M_1, M_5$

$\Rightarrow \Pi M[1, 2, 3, 5, 7] = \sum m[0, 4, 6]$

It is not equal to $\bar{F}$ hence option (c) is False.

Option d: $x\bar{y} + \bar{z}$

	x	y	z	
From term 1 $\Rightarrow$	1	0	x	$\Rightarrow m_4, m_5$
From term 2 $\Rightarrow$	x	x	0	$\rightarrow m_0, m_2, m_4, m_6$

$\Rightarrow \sum m[0, 2, 4, 5, 6]$

Hence option (d) is also True.

Answer : (a), (b) & (d)

47. Let P be an array containing n integers, Let t, be the lowest upper bound on the number of comparisons of the array elements, required to find the minimum and maximum values in an arbitrary array of n elements. Which one of the following choices is correct?

(a) $t > 2n - 2$

(b) $t > \lceil \log_2 (n) \rceil$ and $t \le n$

(c) $t > n$ and $t \le 3\left\lfloor \frac{n}{2} \right\rfloor$

(d) $t > 3\left\lfloor \frac{n}{2} \right\rfloor$ and $t \le 2n - 2$

47. Ans: (c)

Sol: By applying divide & conquer method or tournament method, the number of element comparisons are $\frac{3n}{2} - 2$

48. Consider the following C code segment:

a = b + c;

e = a + 1;

d = b + c;

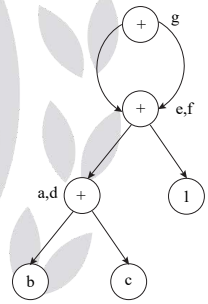
f = d + 1;

g = e + f ;

If a compiler, this code segment is represented internally as a directed acyclic graph (DAG). The number of nodes in the DAG is _____

48. Ans: 6

Sol: The DAG is



The number of nodes = 6.

49. Consider the two statements.

S_1: There exist random variables X and Y such that $(E[(X–E(X))(Y–E(Y))])^2 > Var[X]\ Var[Y]$

S_2: For all random variables X and Y

$Cov[X, Y] = E[\,|\,X–E[X]\,|\,|\,Y– E[Y]\,|]$

Which one of the following choices is correct?

(a) Both S_1 and S_2 are false

(b) S_1 is false, but S_2 is true

(c) Both S_1 and S_2 are true

(d) S_1 is true, but S_2 is false

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49. Ans: (b)

Sol: The covariance between x & y is

$Cov(x, y) = E[(x-E[x])\,(y-E[y])]$

But $Cov(x, y) \neq E[|x-E[x]|\,|y-E[y]|]$

So, S_2 is False

The correlation coefficient 'r' is

$$r = \frac{Cov(x, y)}{\sigma_x\,\sigma_y},\ -1 \le r \le 1$$

we know that $r^2 \le 1$

$$\left[\frac{Cov(x, y)}{\sigma_x\,\sigma_y}\right]^2 \le 1$$

$$\frac{[Cov(x, y)]^2}{\sigma_x^2\,\sigma_x^2} \le 1$$

$[Cov(x, y)]^2 \le \sigma_x^2\,\sigma_y^2$

$(E[(x-E(x))\,(y-E(y))])^2 \le Var(x)\,Var(y)$

So, S_1 is False

50. Consider the relation R(P, Q, S, T, X, Y, Z, W) with the following functional dependencies.

$PQ \rightarrow X$; $P \rightarrow YX$; $Q \rightarrow Y$; $Y \rightarrow ZW$

Consider the decomposition of the relation R into the constituent relations according to the following two decomposition schemes.

D_1: R=[(P,Q,S,T); (P,T,X); (Q,Y); (Y,Z,W)]

D_2: R=[(P,Q,S); (T, X); (Q,Y); (Y,Z,W)]

Which one of the following options is correct?

(a) D_1 is a lossy decomposition, but D_2 is a lossless decomposition.

(b) Both D_1 and D_2 are lossy decompositions.

(c) D_1 is a lossless decomposition, but D_2 is a lossy decomposition.

(d) Both D_1 and D_2 are lossless decompositions.

50. Ans: (c)

Sol: **Decomposition D_1**

$R_1(PQST)\ R_2(PTX)\ R_3(QY)\ R_4(YZW)$

$R_1 \cap R_2 = PT^+ = PTXYZW$; determining attributes of R_2

$[(R_1 \text{join} R_2) \cap R_3] = Q^+ = QYZW$; determining attributes of R_3

$[(R_1 \text{join} R_2 \text{join} R_3) \cap R_4] = Y^+ = YZW$; determining attributes of R_4

$\therefore$ The decomposition D_1 is lossless.

Decomposition D_2

$R_1(PQS)\ R_2(TX)\ R_3(QY)\ R_4(YZW)$

$(R_1 \text{join} R_3 \text{join} R_4) \cap R_2 = \phi$

$\therefore$ The decomposition D_2 is lossy.

51. In the context of operating systems, which of the following statements is/are correct with respect to paging?

(a) Page size has no impact on internal fragmentation.

(b) Paging helps solve the issue of external fragmentation.

(c) Paging incurs memory overheads

(d) multi-level paging is necessary to support pages of different sizes

51. Ans: (b) & (c)

Sol: Paging overcomes external fragmentation. Never will have internal fragmentation. P.T.S acts as memory overhead.

52. A five-stage pipeline has stage delays of 150, 120, 150, 160 and 140 nanoseconds. The registers that are used between the pipeline stages have a delay of 5 nanoseconds each.

The total time to execute 100 independent instructions on this pipeline, assuming there are no pipeline stalls, is _____ nanoseconds.

52. Ans: 17160

Sol: $T_{seg} = 160 + 5 = 165$ ns

$n = 100,\ K = 5$

$t_p = (k + n - 1) \times T_{seg}$

$= 104 \times 165$ ns

$= 17,160$ ns

53. Consider the following ANSI C program.

```
# include<stdio.h>
int main( )
{
   int i, j, count;
   count =0;
   i = 0;
   for( j= –3; j<=3; j++)
   {
       if((j >= 0) && (i++))
       count = count + j;
    }
   count = count + i;
   printf("%d", count);
   return 0;
}
```

Which one of the following options is correct?

(a) The program will not compile successfully.

(b) The program will compile successfully and output 13 when executed.

(c) The program will compile successfully and output 8 when executed.

(d) The program will compile successfully and output 10 when executed.

53. Ans: (d)

Sol: Intially:

count = 0; i = 0

for loop

j = –3 ⇒ after iteration–1 : j = –2, i = 0, count=0

j = –2 ⇒ after iteration–2 : j = –1, i = 0, count=0

j = –1 ⇒ after iteration–3 : j = 0, i = 0, count=0

j = 0 ⇒ after iteration–4 : j = 1, i = 1, count=0

j = 1 ⇒ after iteration–5 : j = 2, i = 2, count=1

j = 2 ⇒ after iteration –6 : j = 3, i = 3, count=3

j = 3 ⇒ after iteration–7 : j = 4, i = 4, count=6

finally, count = count+1

hence, count =10

*/

54. Consider a computer system with a byte-addressable primary memory of size 2^{32} bytes. Assume the computer system has a direct-mapped cache of size 32KB(1 KB = 2^{10} bytes), and each cache block is of size 64 bytes.

The size of the tag field is _____ bits.

54. Ans: 17

Sol: Tye of memory Addressing is Byte Addressable

Main memory = 2^{32} Bytes

Type of Mapping is Direct Map

size of cache = 32 KB = 2^{15} Bytes.

Main memory Address size = 32 bits

(MA)

Cache Memory Address size = 15 bits

(CA)

∴Tag field size = MA – CA = 17 bits

Answer = 17.

55. Define R_n to be the maximum amount earned by cutting a rod of length n meters into one or more pieces of integer length and selling them. For i>0, let p[i] denote the selling price of a rod whose length is i meters. Consider the array of prices:

p[1] = 1, p[2] = 5, p[3] = 8, p[4] = 9, p[5] = 10, p[6] = 17, p[7] = 18

Which of the following statements is/are correct about R_7?

(a) R_7 is achieved by three different solutions

(b) R_7 = 19

(c) R_7 cannot be achieved by a solution consisting of three pieces

(d) R_7 = 18

55. Ans: (a) & (d)

Sol: This is Rod cutting problem. Suppose you have a rod of length n, and you want to cut up the rod and sell the pieces in a way that maximizes the total amount of money you get.

$R_7 = 18$ is maximum.

We can achieve it by three ways :

Way 1 : Take P[7]

Way 2 : Take P[6] , P[1]

Way 3 : Take P[3], P[2], P[2]

So, option A,D are correct.

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