COMPUTER SCIENCE AND INFORMATION TECHNOLOGY (CS, SET-1)

GENERAL APTITUDE (GA)

1. 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) 37

(c) 50

(d) 73

Ans. c

Exp:

Sum of Ratio = 7 + 3 = 10

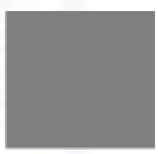
So, total number of students will be a multiple of 10.

Hence, only 1 option is available, i.e., option c.

2 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) 

Ans. a

exp:

According to line segment in case of a line segment will fall outside the polygon. So, a should be the answer.

3. 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?

(a) (i) is grammatically correct and (ii) is unambiguous

(b) (i) is grammatically incorrect and (ii) is unambiguous

(c) (i) is grammatically correct and (ii) is ambiguous

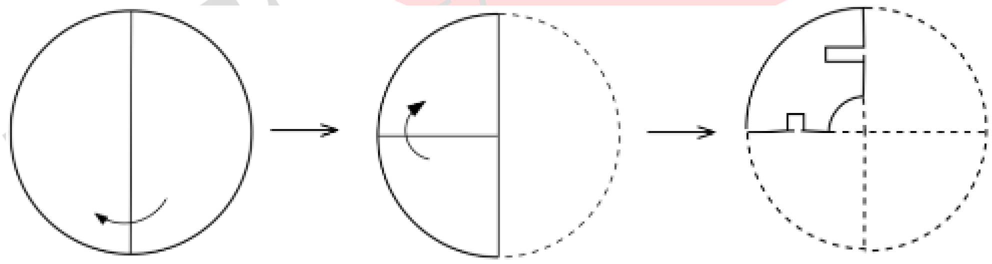
(d) (i) is grammatically incorrect and (ii) is ambiguous

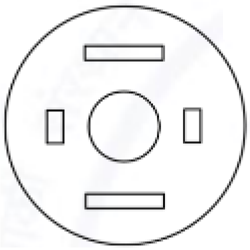
Ans. c

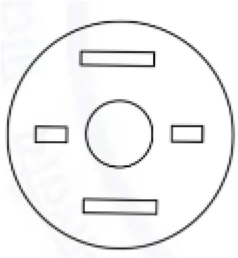
Exp:

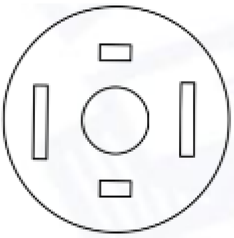
Everybody is singular and takes singular verb is, first statement is correct and the purpose of invitation is unclear so second statement is vague and that sounds ambiguous.

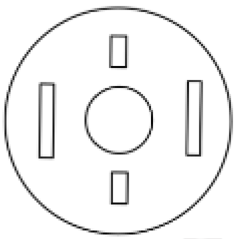
4. A circular sheet of paper is folded along the lines in the directions shown. The paper, after being punched in the final folded state as shown and unfolded in the reverse order of folding, will look like _______.



(a) 

(b) 

(c) 

(d) 

Ans. a

exp:

As the paper is folded twice and as per question given if we will cut it into two places, then it will look like as figure no. a.

5. _____ is to surgery as writer is to ________

Which one of the following options maintains a similar logical relation in the above sentence?

(a) Plan, outline

(b) Hospital, library

(c) Doctor, book

(d) Medicine, grammar

Ans. c

Exp:

Doctor is known for surgery so as writer is known for writing books.

Q. 6 – Q. 10 Multiple Choice Question (MCQ), carry TWO marks each (for each wrong answer: – 2/3).

6. We have 2 rectangular sheets of paper, M and N, of dimensions 6 cm x 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) $\frac{\pi}{2}$

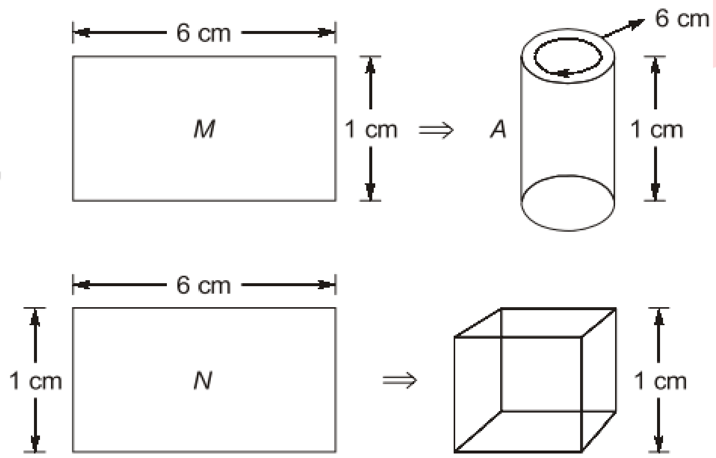
(b) $\frac{3}{\pi}$

(c) $\frac{9}{\pi}$

(d) 3π

Ans. c

Exp:



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

Now, $2\pi r = 6$ (figure A)

$$r = \frac{3}{\pi}$$

Volume of cylinder = $\pi \times \frac{3}{\pi} \times \frac{3}{\pi} \times 1 = \frac{9}{\pi}$

Volume of cube = $(1)^3$

Ratio = $\frac{\frac{9}{\pi}}{1} = \frac{9}{\pi}$

7.

Item	Cost Price	Profit %	Marked Price
P	5400	—	5860
Q	—	25	10000

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 $\left(\text{Profit}\,\% = \frac{\text{selling price} - \text{Cost}}{\text{Cost}} \times 100\right)$.

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

(a) 25

(b) 12.5

(c) 10

(d) 5

Ans. c

Exp:

$CP_P = 5400$, $MP_P = 5860$

$\frac{5400 \times 4}{5} = CP_Q \Rightarrow CP_Q = 7200$

$SP_Q = ?$

Profit % = $\frac{\text{Profit}}{\text{CP}} \times 100$ [for Q]

$25 = \left(\frac{SP - 7200}{7200}\right) \times 100$

$SP_Q = 9000$

Discount Q = $MP_Q - SP_Q = 1000$

Discount % = $\frac{1000}{10,000} \times 100 = 10\%$

8. 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) 0.3024

(b) 0.4235

(c) 0.6976

(d) 0.8125

Ans. c

Exp:

Total number of ways to take out the chocolates are = $10 \times 10 \times 10 \times 10 \times 10 = 10^5$

Number of ways in which no chocolate will be identical = $10 \times 9 \times 8 \times 7 \times 6 = 30240$

Probability in which no chocolate will be identical = $30240/10^5$

Probability in which at least two chocolate are identical = $1 - (30240/10^5) = 0.6976$

9. 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 I is correct

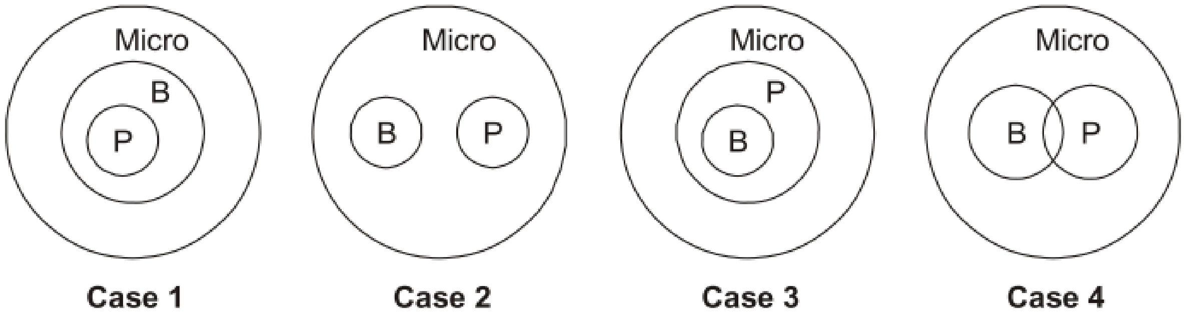
(b) Only conclusion II is correct

(c) Either conclusion I or II is correct.

(d) Neither conclusion I nor II is correct.

Ans. d

Exp:



None of the two conclusions will satisfy all the 4 cases.

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) The proposed AOM addresses the core problems that cause obesity.

(b) If obesity reduces, poverty will naturally reduce, since obesity causes poverty.

(c) AOM are addressing the core problems and are likely to succeed.

(d) AOM are addressing the problem superficially.

Ans. c

Exp:

Superficially is the deciding key word which means apparently/seemingly.

Computer Science and Information Technology

(CS, Set-1)

Q.1 – Q.10 Multiple Choice Question (MCQ), carry ONE mark each (for each wrong answer: – 1/3).

1. Suppose that L_1 is a regular language and L_2 is a context-free language. which one of the following languages is NOT necessarily context-free ?

(a) $L_1 \cap L_2$

(b) $L_1 \cdot L_2$

(c) $L_1 - L_2$

(d) $L_1 \cup L_2$

Ans. c

Exp:

$L_1 \rightarrow$ Reg

$L_2 \rightarrow$ Context-free

(a) $L_1 \cap L_2 = \text{Reg} \cap \text{CFL} = \text{CFL}$

(b) $L_1 \cdot L_2 = \text{Reg} \cdot \text{CFL} = \text{CFL}$

(c) $L_1 - L_2 = L_1 \cap \overline{L}_2 = \text{Reg} \cap \overline{\text{CFL}} = \text{Reg} \cap \overline{\text{CSL}} = \text{Reg} \cap \text{CSL} = \text{CSL}$

(d) $L_1 \cup L_2 = \text{Reg} \cup \text{CFL} = \text{CFL}$

So, (c) is not necessarily CFL.

2. 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) $t > 3\left\lceil \frac{n}{2} \right\rceil$ and $t \leq 2n - 2$

(c) $t > n$ and $t \leq 3\left\lceil \frac{n}{2} \right\rceil$

(d) $t > \lceil \log_2(n) \rceil$ and $t \leq n$

Ans. c

Exp:

$t > 3\left\lceil \frac{n}{2} \right\rceil$ and $t \le 2n - 2$

Using straight max-min algo, WC number of comparisons = 2n – 2

Using divide and conquer min-max algo, WC number of comparisons = $\frac{3n}{2} - 2$.

3. 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_3, f_2, f_1

(b) f_2, f_1, f_3

(c) f_1, f_2, f_3

(d) f_2, f_3, f_1

Ans. d

Exp:

$f_2 : n^{\log n}$ $f_3 : n^{\sqrt{n}}$

$\log(n^{\log n})$ $\log(n^{\sqrt{n}})$

$= (\log n) \cdot (\log n)$ $= \sqrt{n} \cdot \log n$

$\therefore$ $n^{\log n} = O(n^{\sqrt{n}})$ $(f_2 < f_3)$

$f_1 = 10^n \leftarrow$ exponential function

$\therefore$ $f_1 > f_3 > f_2$

In increasing order of asymptotic growth rate.

4. 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 traversal of the activation tree.

Which one of the following options is correct?

(a) S_1 is true and S_2 is false

(b) S_1 is false and S_2 is true

(c) S_1 is true and S_2 is true

(d) S_1 is false and S_2 is false

Ans. c

Exp:

5. 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 false

(b) S_1 is false and S_2 is true

(c) S_1 is true and S_2 is true

(d) S_1 is false and S_2 is false

Ans. c

Exp:

S_1 : Every SLR(1) is unambiguous but every unambiguous is not SLR(1). So, S_1 is true.

S_2 : Using CYK algorithm which takes at most $O(n^3)$ time to parse a string, where n is the length of the string. So, S_2 is true.

Both S_1 is true and S_2 is true.

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

(a) 15

(b) 21

(c) D2

(d) 528

Ans. a

Exp:

$(210)_3 = 3^2 \times 2 + 3^1 \times 1 + 3^0 \times 0 = (21)_{10}$

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

7. Let p and q be two propositions. Consider the following two formulae in propositional logic.

S_1 : $(-p \wedge (p \wedge q)) \rightarrow q$

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

Which one of the following choices is correct?

(a) Both S_1 and S_2 are tautologies.

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

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

(d) Neither S_1 nor S_2 is a tautology.

Ans. b

Exp:

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

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

$S_1 : [p'(p + q)] \rightarrow p$

$\equiv (p'p + p'q) \rightarrow q$

$\equiv p'q \rightarrow q$

$\equiv (p'q)' + q$

$\equiv p + q' + q$

$\equiv p + 1$

$\equiv 1$ (tautology)

$S_2 : q \rightarrow (p'(p + q))$

$\equiv q \rightarrow (p'p + p'q)$

$\equiv q \rightarrow p'q$

≡ q' + p'q

≡ (q' + p')(q' + q)

≡ q' + p' (contingency) (not a tautology)

8. 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) Both S_1 and S_2 are true.

(b) S_1 is true and S_2 is false

(c) S_1 is false and S_2 is true

(d) Both S_1 and S_2 are false

Ans. c

Exp:

ARP request is broadcasting.

ARP reply is unicasting.

9. 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) Selection sort

(b) Mergesort

(c) Insertion sort

(d) Quicksort using the last element as pivot

Ans. c

Exp:

Given array already sorted.

∴ Insertion sort takes least number of comparisons $\theta(n)$.

Since, for a number which is to be inserted in the already sorted array, only 1 comparison will be required.

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

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

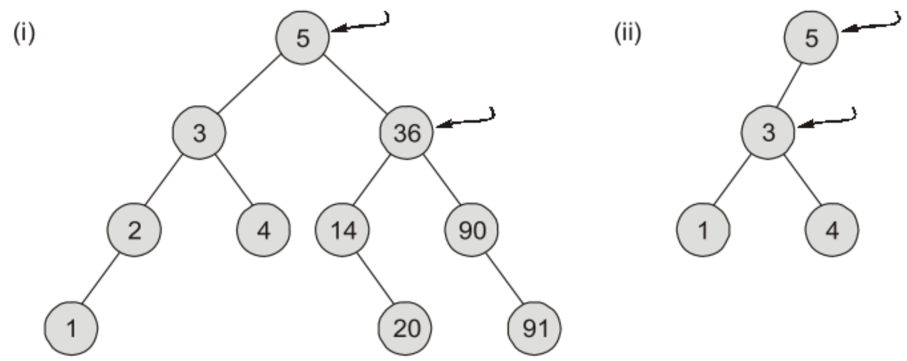
(b) $\Theta(n)$

(c) $\Theta(\log n)$

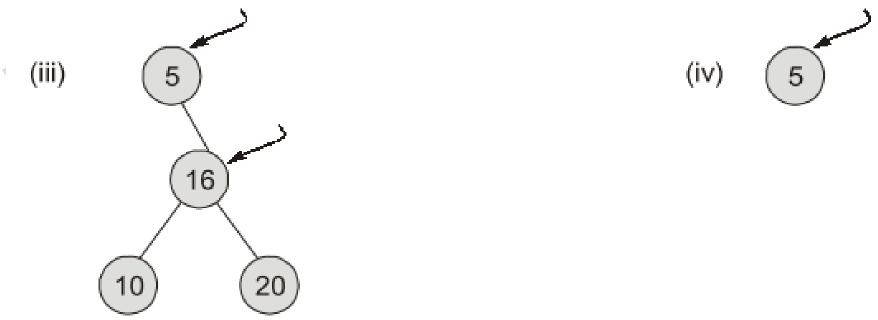
(d) $\Theta(1)$

Ans. d

Exp:



⇒ 5 is definitely lesser than max element ⇒ 3 is definitely lesser than max element



⇒ 5 is definitely lesser than max element ⇒ No such element

In any case, we can find one element that is less in just 2 seeks ⇒ $\theta(1)$

Q.11 – Q.15 Multiple Select Question (MSQ), carry ONE mark each (no negative marks).

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

(a) Paging help solve the issue of external fragmentation.

(b) Page size has no impact on internal fragmentation

(c) Paging incurs memory overheads.

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

Ans. a, c

Exp:

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

(a) L = $\{\langle M \rangle \mid$ M is a DFA such that $L(M) = \emptyset\}$

(b) L = $\{\langle M \rangle \mid$ M is a DFA such that $L(M) = \Sigma^*\}$

(c) L = $\{\langle M \rangle \mid$ M is a PDA such that $L(M) = \emptyset\}$

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

Ans. d

Exp:

(a) : Emptiness problem for Regular → Decidable

→ Recursive

(b) : Completeness problem for Regular → decidable

→ Recursive

(c) : Emptiness problem for CFL's → Decidable

→ Recursive

(d) : Completeness problem for CFL's → Undecidable

→ Not recursive

13. Suppose a database system crashes again while recovering from a previous crash. Assume checkpointing is not done by the database either during the transactions or during recovery.

Which of the following statements is/are correct?

(a) The same undo and redo list will be used while recovering again.

(b) The system cannot recover any further.

(c) All the transactions that are already undone and redone will not be recovered again.

(d) The database will become inconsistent.

Ans. a

14. 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) exit

(b) malloc

(c) sleep

(d) strlen

Ans. a, c

15. 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) Creation of a new file in foo

(b) Deletion of an existing file from foo

(c) Renaming of an existing file in foo

(d) Opening of an existing file in foo

Ans. a, c

Q.16 – Q.25 Numerical Answer Type (NAT), carry ONE mark each (no negative marks).

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

Ans. 11

Exp:

In a connected planar graph,

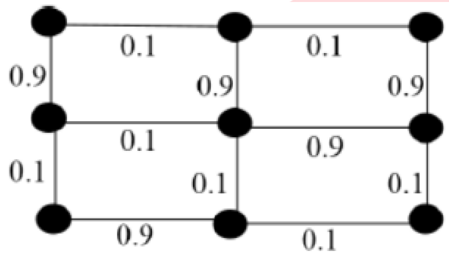
r = e – n + 2

Here, n = 8, r = 5

∴ 5 = e – 8 + 2

e = 11

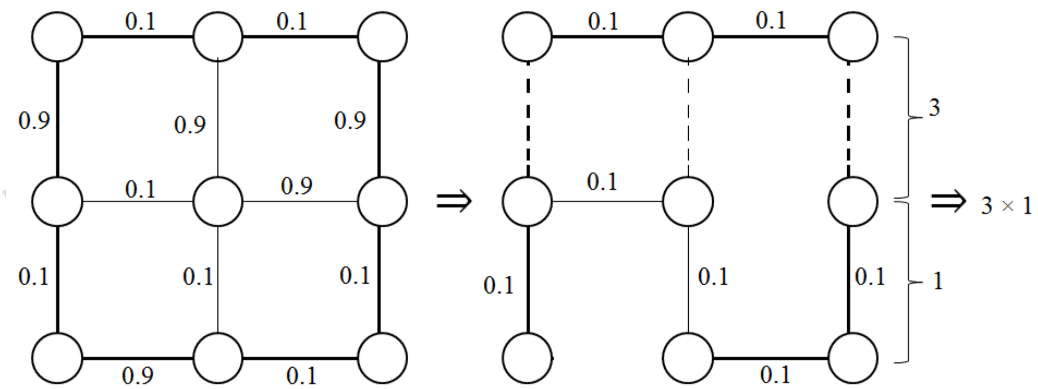
17. Consider the following undirected graph with edge weights as shown:



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

Ans. 3

Exp:



18. 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 ________.

Ans. 0.35 – 0.39

Exp:

Let t = {lifetime of component} and μ = 2

Expected lifetime = $\frac{1}{\mu}$ and $f(t) = \begin{cases} \mu e^{-\mu t}, & t > 0 \\ 0, & \text{otherwise} \end{cases}$

$$P\left(t > \frac{1}{\mu}\right) = \int_{\frac{1}{\mu}}^{\infty} f(t)\,dt = \int_{\frac{1}{\mu}}^{\infty} \mu e^{-\mu t} dt = -\left[e^{-\mu t}\right]_{1/2}^{\infty} = \frac{1}{e} = 0.36$$

19. 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 at least one job.

The number of ways in which this can be done is _________.

Ans. 65

Exp:

Let computers be A, B and C

Toughest job assigned to fastest computer (Say, A) is 1 way.

Easiest job assigned to shortest computer (Say, B) is 1 way.

Remaining 4 jobs to be assigned to 3 computers so that the computer C gets at least one job, since A and B already assigned a job.

Number of ways 4 jobs assigned to 3 computers = 3^4 .

Number of ways 4 jobs assigned to 3 computers, so that computer C does not get any job = 2^4 .

Required number of ways = $3^4 - 2^4$ = 65 ways

20. 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 ________.

Ans. 0.25

Exp:

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

On applying L'Hospital's rule, we get

$$= \lim_{x \to -3} \left[\frac{\dfrac{2}{2\sqrt{2x+22}}}{1} \right] = \lim_{x \to -3} \left[\frac{1}{\sqrt{2x+22}} \right] = 0.25$$

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

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

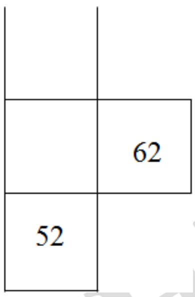
Consider the following sequence of operations on an empty queue.

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

The value of s + q is ________.

Ans. 86

Exp:



S = 62

R = 24

43	24	57

S + R = 86

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

The size of the tag field is ________ bits.

Ans. 17

Exp:

MM size = 2^{32} B

Addressable size = $\log_2 2^{32} = 32$ bit

Direct mapped

CM size = 32 KB

Block size = 64 B

$\therefore$ Number of lines = $\frac{32K}{64} \Rightarrow \frac{2^{15}}{2^6} = 2^9$

Address format :

32 bit

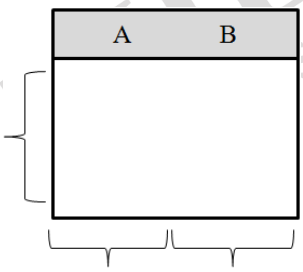
Tag	LO	WO
17 bit	$\text{Log}_2 2^9$ → 9 bit	$\text{Log}_2 64 = 6$ bit

23. 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 _________.

Ans. 820

Exp:



6 to 20 1 to 20

$\Rightarrow$ 15 distinct $\Rightarrow$ 20 distinct

$\frac{1200}{15} = 80$ $\frac{1200}{20} = 60$

Each ‘A’ can repeat 80 times

Each ‘B’ can repeat 60 times

$\sigma_{(A > 10) \vee (B = 18)}(r)$

min ⇒ 10 × 80 = 800

max ⇒ 10 × 80 + 60 = 860

∴ Average = $\frac{800+860}{2} = 830$

24. 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 : 11110000000000000000000

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 ________.

Ans. –7.75

Exp:

Value: $(-1)^S (1.M) \times 2^{BE\text{-}Bias}$

$(-1)^1 (1.11100...) \times 2^{10000001 - 127}$

$(-1.1111) \times 2^{129 - 127}$

-1.1111×2^2

-111.11

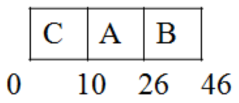
$(-7.75)_{10}$

25. 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.

Ans. 12

Exp:

WT	CT	P.No.	AT	BT
0	10	A	0	16
26	46	B	0	20
10	26	C	0	10



Average writing time = $\frac{0+26+10}{3}=12$

Q.26 – Q.39 Multiple Choice Question (MCQ), carry TWO mark each (for each wrong answer: –2/3).

26. 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 → bool ID {record that ID.lexeme is of type bool}

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

E → !E_1 {check that E_1.type = bool; set E.type := bool}

E → ID {set E.type : = int}

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

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

(b) The action can be used to type-check syntactically correct integer variable declarations and integer expressions.

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

(d) The actions will lead to an infinite loop.

Ans. b

Exp:

1. P → D*E*

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

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

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

5. E → !E_1 {check that E_1.type = bool; set E.type := bool}

6. E → ID {set E.type : = int}

Rules 2 and 3 are used for entry into the symbol table. Rule 4 is used for type checking of the integer expression. But, in rule 6 only int type is set.

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

empAge(empNo, age)

Consider the following relational algebra expression:

$$\Pi_{empNo} (empAge \bowtie_{(age>age1)} \rho_{empNo1, age1} (empAge))$$

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 not the minimum

(d) Employee numbers of all employees whose age is the minimum.

Ans. c

Exp:

empAge(empNo, age)

$$\Pi_{empNo} (empAge \bowtie_{(age>age1)} \rho_{empNo1, age1} (empAge))$$

Retrieve empNo values of emptAge those are having ‘age’ greater than some age.

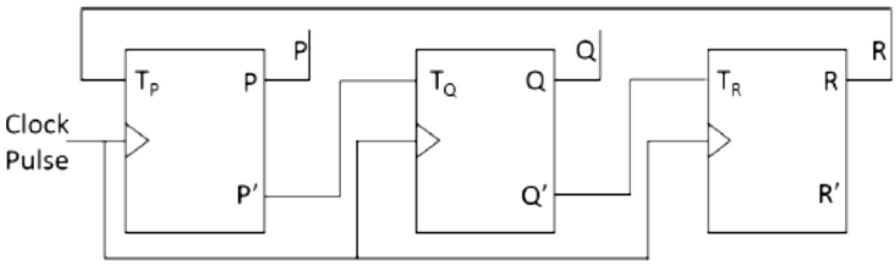
⇓

Retrieve Employee Number (empNo) of all employee whose age is greater than some employee’ age.

⇓

Employee number of all employees whose age is not the minimum. [Since it is greater than atleast 1 age].

28. 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, 000

(b) 001, 010, 111

(c) 011, 101, 111

(d) 001, 010, 000

Ans. a

Exp:

Clock	Present state			Flip-flop inputs			Next state		
	P	Q	R	$T_P = R$	$T_Q = \bar{P}$	$T_R = \bar{Q}$	P^+	Q^+	R^+
1	0	0	0	0	1	1	0	1	1
2	0	1	1	1	1	0	1	0	1
3	1	0	1	1	0	1	0	0	0

∴ Next three states of counter are 011, 101, 000

29. Assume that a 12-bit Hamming codeword consisting of 8-bit data and 4 check bits is $d_8d_7d_6d_5c_8d_4d_4d_3d_2c_4d_1c_2c_1$, 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 0 and y is 1

(c) x is 1 and y is 0

(d) x is 1 and y is 1

Ans. a

Exp:

1	2	3	4	5	6	7	8		c_1	c_2	c_4	c_8
1	0	1	0	x	0	1	1		0	1	0	y

c_1 = 1	3	5	7	9	11
0	1	0	0	x	1

$\xleftrightarrow{x=0}$

1	2	3	4	5	6	7	8	9	10	11	12
0	1	1	0	0	1	0	y	x	0	1	1

c_8 = 8	9	10	11	12
0	0	0	1	1

$\xleftrightarrow{y=0}$

30. Consider the following recurrence relation.

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

Which one of the following options is correct?

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

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

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

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

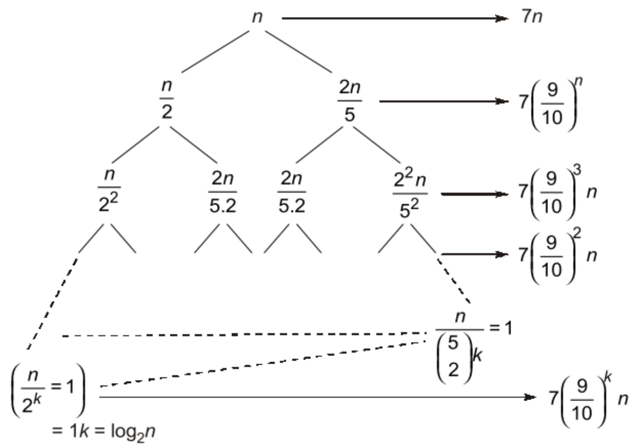
Ans. c

Exp:

$$T(n) = 7n\left[1 + \frac{9}{10} + \left(\frac{9}{10}\right)^2 + \left(\frac{9}{10}\right)^3 + \ldots + \left(\frac{9}{10}\right)^k\right]$$

$$= \frac{7n\left[1 - \left(\frac{9}{10}\right)^{k+1}\right]}{1 - \frac{9}{10}} = \frac{7n}{\frac{1}{10}}\left[1 - \left(\frac{9}{10}\right)^{\log_2 n + 1}\right] \qquad \text{(Decreasing term)}$$

$\therefore \quad T(n) = \theta(n)$



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

$$S \to d\,a\,T \mid R\,f$$

$$T \to a\,S \mid b\,a\,T \mid \epsilon$$

$$R \to c\,a\,T\,R \mid \epsilon$$

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 → R f ② S → R f ③ T → ϵ ④ T → ϵ

(b) ① blank ② S → R f ③ T → ϵ ④ T → ϵ

(c) ① S → R f ② blank ③ blank ④ T → ϵ

(d) ① blank ② S → R f ③ blank ④ blank

Ans. a

Exp:

$S \to daT \mid Rf$

$T \to aS \mid baT \mid \epsilon$

$R \to caTR \mid \epsilon$

First (S) = {d, c, f}   Follow (S) = {c, f, $}

First (T) = {a, b, ϵ}   Follow (T) = {c, f, $}

First (R) = {c, ϵ}   Follow (R) = {f}

	a	b	c	d	f	$
S			① $S \rightarrow Rf$	$S \rightarrow daT$	② $S \rightarrow Rf$	
T	$T \rightarrow aS$	$T \rightarrow baT$	③ $T \rightarrow \epsilon$		$T \rightarrow \epsilon$	④ $T \rightarrow \epsilon$
R			$R \rightarrow caTR$		$R \rightarrow \epsilon$	

① $S \rightarrow Rf$ ② $S \rightarrow Rf$ ③ $T \rightarrow \epsilon$ ④ $T \rightarrow \epsilon$

32. 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) S_1 is conflict serializable, and S_2 is not conflict serializable

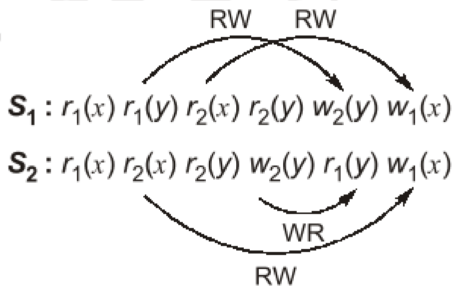
(b) S_1 is not conflict serializable, and S_2 is conflict serializable

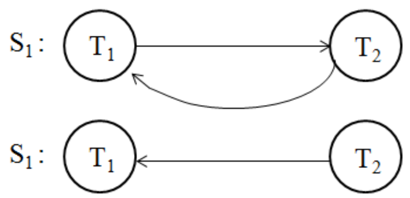
(c) Both S_1 and S_2 are conflict serializable

(d) Neither S_1 nor S_2 is conflict serializable.

Ans. b

Exp:





Cycle exists in precedence graph
∴ Not conflict serializable.

No Cycle
∴ Conflict serializable.

S_1 is not conflict serializable, and S_2 is conflict serializable

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

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

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

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 lossless decomposition, but D_2 is a lossy decomposition

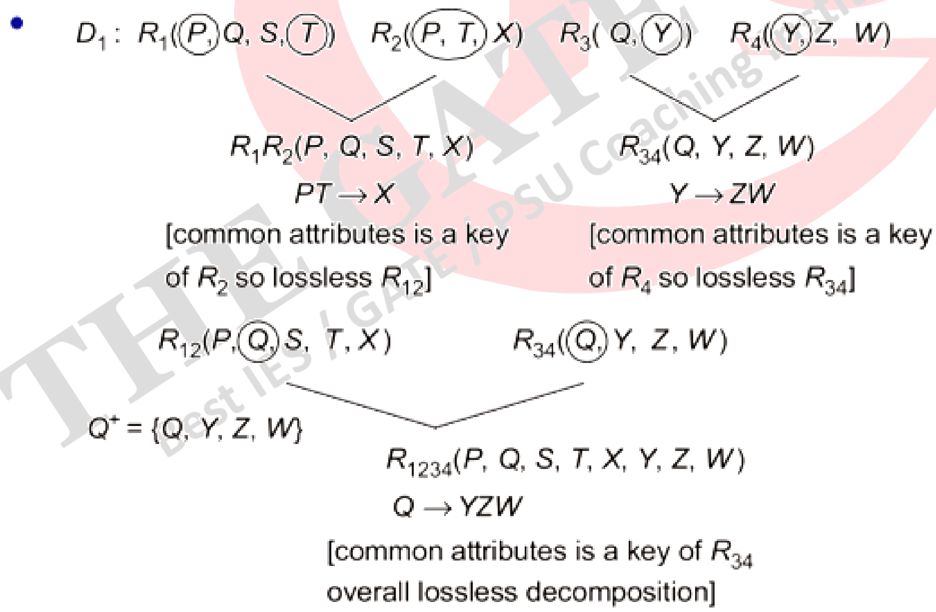
(b) D_1 is a lossy decomposition, but D_2 is a lossless decomposition

(c) Both D_1 and D_2 are lossless decomposition.

(d) Both D_1 and D_2 are lossy decompositions

Ans. a

Exp:



- $D_2: R_1(P, Q, S) \quad R_2(T, X) \quad R_3(Q, Y) \quad R_4(Y, Z, W)$

  $R_1(T, X) \quad R_1(P, Q, S) \quad R_{34}(Q, Y, Z, W)$

  $Y \rightarrow ZW$ [lossless R_{34}]

  $R_2(T, X) \quad R_{134}(P, Q, S, Y, Z, W)$ $Q \rightarrow YZW$ [lossless R_{134}]

  No common attribute $\Rightarrow$ Lossy

34. Let G be a group of order 6, and H be a subgroup of G such that 1 < |H| < 6. Which one of the following options is correct?

(a) Both G and H are always cyclic.

(b) G may not be cyclic, but H is always cyclic

(c) G is always cyclic, but H may not be cyclic

(d) Both G and H may not be cyclic.

Ans. b

Exp:

|G| = 6

H is subgroup, so by Lagrange's theorem

|H| = 1, 2, 3 or 6 (Divisor's of 6)

Now it is given that 1 < | H| < 6

or |H| = 2 or 3

Since 2 and 3 are both prime and since every group of prime order is cyclic, H is surely cyclic.

But order of |G| = 6 which is not prime.

So, G may or may not be cyclic.

So, G may not be cyclic, but H is always cyclic.

35. Consider the two statements.

S_1 : There exist random variables X and Y such that

$$(\mathbb{E}[(X - \mathbb{E}(X))(Y - \mathbb{E}(Y))])^2 > \text{Var}[X]\,\text{Var}[Y]$$

S_2 : For all random variables X and Y,

$$\text{Cov}[X, Y] = [\,|X - \mathbb{E}[X]|\,|Y - \mathbb{E}[Y]|\,]$$

Which one of the following choices is correct?

(a) Both S_1 and S_2 are true

(b) S_1 is true, but S_2 is false

(c) S_1 is false, but S_2 is true.

(d) Both S_1 and S_2 are false.

Ans. d

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

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

Which one of the following statements is true?

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

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

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

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

Ans. a

Exp:

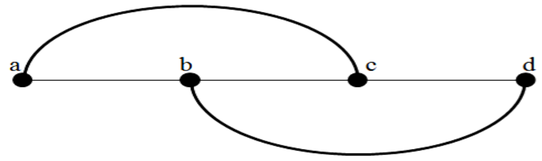
$$N_{ij} = \begin{cases} 1 & if\ M_{ij} > 0\ or\ P_{ij} > 0,\ where\ P = M^2 \\ 0 & \text{otherwise} \end{cases}$$

Means G_2 will have not only all the edges of in G, but also will have edges connecting vertices in G which have a path of length 2, since M^2 will have all edges between u and v if there is a path of length 2 between shown in G.

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

Consider graph below with dia(G) = 3

Now G_2 will connect all paths of length 2 with edges and will be



Now dia(G_2) = 2

But dia(G) = 3

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

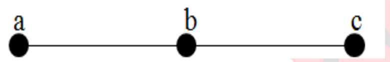
$2 \leq \lceil 1.5 \rceil$

$2 \leq 2$ Condition satisfied.

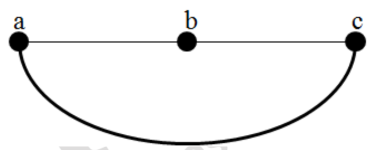
So, option a is correct.

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

Let G be the graph shown below with dia(G) = 2



Now G_2 will be



Since (a, c) has a path of length 2 in G, G_2 will have an edge connecting a and c. Now, diameter of G_2 = 1

This violates option (b) condition that dia(G_2) > dia(G)/2.

So, option (b) is false.

Option (c) diam(G_2) = diam(G)

Taking previous example where dia(G) = 3 and dia(G_2) = 2

2 = 3 is false

So, option c is false.

Option (d) diam(G) < diam(G_2) ≤ 2 diam(G)

Taking previous example where dia(G) = 3 and dia(G_2) = 2

$3 \leq 2 \leq 6$

is false.

So, only option (a) is correct.

37. 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 10 when executed.

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

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

Ans. b

Exp:

j = –3, j = –2, j = –1 ⇒ Short circuiting in if((j > = 0) && (i++))

j = 0; i = 0 used but i = 1

j = 1; i = 1 used but i = 2

count = 0 + 1 = 1

j = 2; i = 2 used but i is 3

count = 1 + 2

j = 3; i = 3 used but i = 4

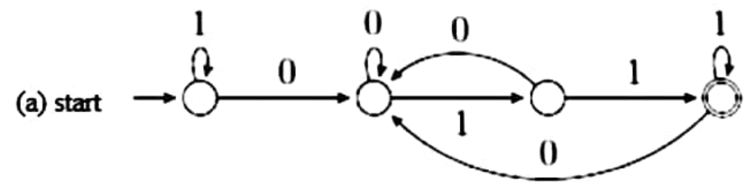
count = 3 + 3 = 6

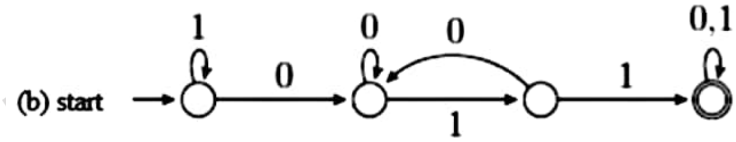
count = 6 + 4 = 10 corresponding to count = count + i

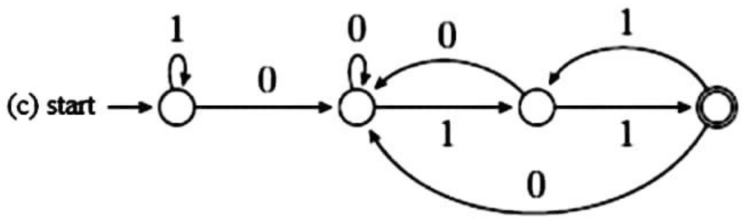
38. Consider the following language.

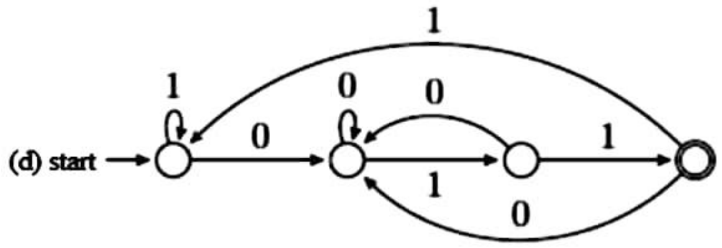
$$L = \{w \in \{0, 1\}^* \mid w \text{ ends with the substring } 011\}$$

Which one of the following deterministic finite automata accepts L ?





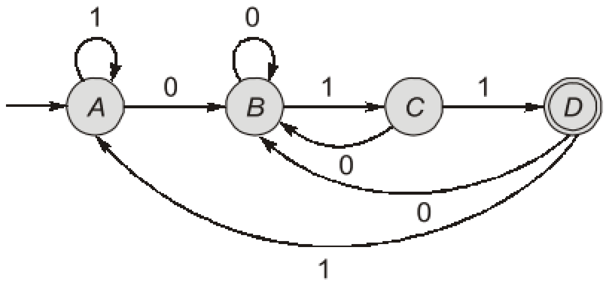




Ans. d

Exp:

Since 4 states are required in minimal DFA for this language "Ending with 011", and since all given DFA's have 4 states, the answer must be same as minimal DFA. The minimal DFA for this language is given below:



39. For a Turing machine M, $\langle M \rangle$ denotes an encoding of M. Consider the following two languages.

$$L_1 = \{\langle M \rangle \mid \text{M takes more than 2021 steps on all inputs}\}$$

$$L_2 = \{\langle M \rangle \mid \text{M takes more than 2021 steps on some input}\}$$

Which one of the following options is correct?

(a) Both L_1 and L_2 are decidable

(b) L_1 is decidable and L_2 is undecidable

(c) L_1 is undecidable and L_2 decidable

(d) Both L_1 and L_2 are undecidable.

Ans. a

Exp:

$$L_1 = \{\langle M \rangle \mid \text{M takes more than 2021 steps on all inputs}\}$$

$$L_2 = \{\langle M \rangle \mid \text{M takes more than 2021 steps on some input}\}$$

A Turing machine reads at most 2021 bits of input while making 2021 steps. So, the halting behaviour is completely determined by the first 2021 bits of input. Now the number of strings with 2021 bits is finite and so generate all of them and in finite amount of time we can check if the given TM, M halts on any of these strings.

For L_1 , the algorithm will be as follows :

Does not halts on all of these strings → Yes

Halts on at least one of these strings → No

For L_2 , the algorithm will be as follows,

does not halt or at least one of these strings → Yes

Halts on all of these strings → No

So, both L_1 and L_2 are decidable.

Q.40 – Q.47 Multiple Select Question (MSQ), carry TWO mark each (no negative marks).

40. 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) $R_7 = 18$

(b) $R_7 = 19$

(c) R_7 is achieved by three different solutions.

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

Ans. a, c

Exp:

R7 : Maximum amount earned by cutting rod of length '7' into 1, 2, 3, 4, 5, 6, 7 pieces (whichever way is maximum).

p[7] = 18

p[6] + p[1] = 17 + 1 = 18

(Also, R_7 is achieved by 3 diff. solution)

p[5] + p[2] = 10 + 5 = 15

p[4] + p[3] = 9 + 8 = 17

p[5] + p[1] + p[1] = 10 + 1 + 1 = 12

p[4] + p[2] + p[1] = 9 + 5 + 1 = 15

p[4] + p[1] + p[1] + p[1] = 9 + 1 + 1 + 1 = 12

p[3] + p[4] = 17

p[3] + p[3] + p[1] = 8 + 8 + 1 = 17

p[3] + p[2] + p[2] = 8 + 5 + 5 = 18

(R_7 is achieved by 3 diff. pieces)

p[3] + 4 p[1] = 8 + 4 = 12

p[2] + p[5] = 15

p[2] + p[4] + p[1] = 5 + 9 + 1 = 15

p[2] + p[3] + p[2] = 18

p[2] + 5 p[15] = 5 + 5 = 10

p[2] + p[2] + 3 p[1] = 5 + 5 + 3 = 13

41. 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) Root of T is an articulation point in g if and only if it has 2 or more children.

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

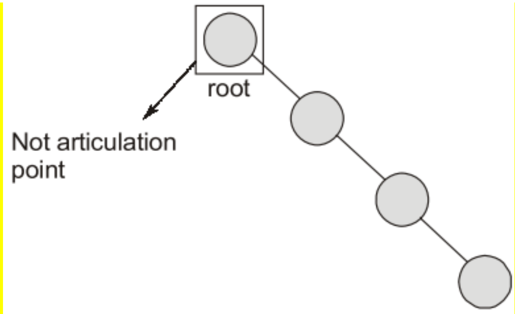
(d) if u is an articulation point in G such that *x* is an ancestor of u in t and y is a descendent of y in T, then all paths from *x* to *y* in G must pass through *u*.

Ans. b

Exp:

(a) False: Check option b for more information.

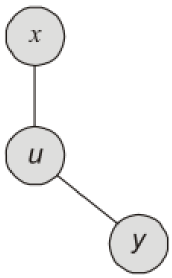
(b) True



We need at least 2 children so that root is articulation point.

(c) False: This can never happen. Leaf will always have degree = 1.

(d) True: u is articulation point. So, removing u disconnects *x* and y. Hence, (d) is true.



42. Consider the following Boolean expression.

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

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

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

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

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

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

Ans. b, c, d

Exp:

$$\bar{F} = \bar{Y}\left(\bar{X}\bar{Z} + X\right) + Y\bar{Z}$$

$$= \bar{Y}\left[\left(X + \bar{X}\right)\right]\left(X + \bar{Z}\right) + Y\bar{Z}$$

$$= \bar{Y}\left[X + \bar{Z}\right] + Y\bar{Z}$$

$$= X\bar{Y} + \bar{Y}\bar{Z} + Y\bar{Z}$$

$= X\bar{Y} + \bar{Z}(\bar{Y} + Y)$

$= X\bar{Y} + \bar{Z}$

Option (b) is matching.

$X\bar{Y} + \bar{Z} = (X + \bar{Z})(\bar{Y} + \bar{Z})$ using distribution property.

So, option (c) is matching.

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

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

$\bar{F} = \overline{(X + Y + Z)} + \overline{(\bar{X} + Y)} + \overline{(\bar{Y} + Z)}$ Using Demorgan's theorem

$= \bar{X}\bar{Y}\bar{Z} + X\bar{Y} + Y\bar{Z}$

Option (d) is matching.

Hence, (b), (c) and (d) are the correct answers.

43. A relation **R** is said to be circular if a**R**b and b**R**c together imply c**R**a.

Which of the following options is/are correct?

(a) If a relation **S** is reflexive and symmetric, 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 circular, then **S** is an equivalence relation.

(d) If a relation **S** is transitive and circular, then **S** is an equivalence relation.

Ans. c

Exp:

Let S be reflexive and circular.

Let us checking symmetry:

Symmetry:

Let *x*Sy

Now since S is reflexive ySy true.

So *x*Sy and ySy is true.

Now by circular property we get, yS*x*

So xSy ⇒ ySx

So S is symmetric.

Transitive:

Let xSy and ySz

Now by circular property we get zSx and by symmetry property proved above, we get

zSx ⇒ xSz

So, xSy and ySz ⇒ xSz

So S is transitive

So S is reflexive, symmetric and transitive and hence an equivalence relation.

So, option c is true.

Option (a): Reflexive and symmetric need not be transitive for example on {1, 2, 3}.

S = {(1, 1), (2, 2), (3, 3), (1, 2), (2, 1), (2, 3), (3, 2)}

is reflexive and symmetric. But it is not transitive because (1, 2) and (2, 3) belong to S but (1, 3) does not.

So, option (a) is false.

Option (b): Let S be circular and symmetric.

Let S be defined on set {1, 2, 3}

Now empty relation is circular and symmetric but not reflexive. So, S need not be an equivalence relation. So, option b is false.

Option (d): Let S be transitive and circular.

Let S be defined on the set {1, 2, 3}

Now empty relation against satisfies transitive and circular but is not reflexive. So, S need not be an equivalence relation.

So, option d is false.

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

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

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

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

Ans. a, b, c

Exp:

(a) **True:** Since broken connections can only be detected by sending data, the receiving side will wait forever. This scenario is called a “half-open connection” because one side realizes the connection was lost but the other side believes it is still active.

(b) **True:** Yes, a TCP Server can listen to same port number even after reboot. For example, the SMTP service application usually listens on TCP port 25 for incoming requests. So, even after reboot the port 25 is assigned to SMTP.

(c) **True:** The situation resolves itself when client tries to send data to server over the dead connection, and server replies with an RST packet (not FIN).

(d) **False:** The situation resolves itself when client tries to send data to server over the dead connection, and server replies with an RST packet (not FIN), causing client to finally to close the connection forcibly.

FIN is used to close TCP connections gracefully in each direction (normal close of connection), while TCP RST is used in a scenario where TCP connections cannot recover from errors and the connection needs to reset forcibly.

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

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

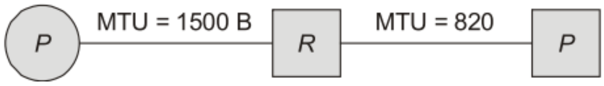
(c) If the second fragment is lost, P is required to resend the whole TCP segment.

(d) TCP destination port can be determined by analysing only the second fragment.

Ans. a, c

Exp:

Data = 1400 B



For First Link – PR – There will be no fragment

For Second Link – RQ

First Fragment = 800 (Data) + 20 (Header) = 820 B

Second Fragment = 1400 – 800 = 600 + 20(H) = 620 B

46. 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 behaviour(s) is/are possible?

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

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

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

(d) There is a deadlock involving all the threads.

Ans. a, b, d

Exp:

(a) True: Each process executed the code sequentially and counter was finally updated to 5.

(b) True: (P_1) first process came executed wait(S); wait(S) counter++ ; was partially executed and the process pre-empted. Other process came updated counter to 4.

Now P_1 came and wrote counter to 1.

(c) False: Not possible at least counter will be 1.

(d) True: All 5 processes executed first wait(S) and are blocked.

47. 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 entries are empty.

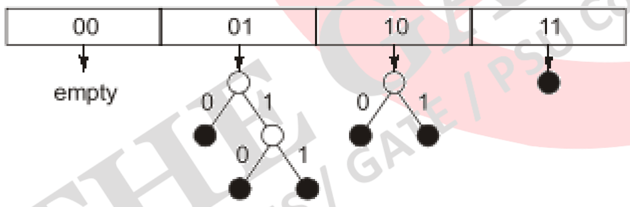
4. Thereafter, when more keys are hashed into it, to resolve collisions, the set of all keys corresponding to a main hash table entry is organized as a binary tree that grows on demand.

5. First, the 3rd least significant bit is used to divide the keys into left and right subtree.

6. To resolve more collisions, each node of the binary tree is further sub-divided into left and right subtree 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

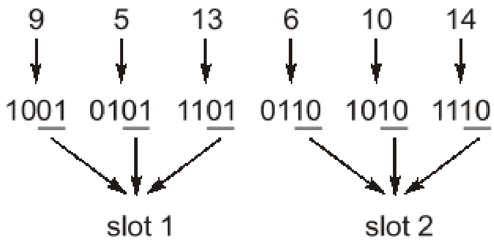
(b) 9, 5, 10, 6, 7, 1

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

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

Ans. c

Exp:

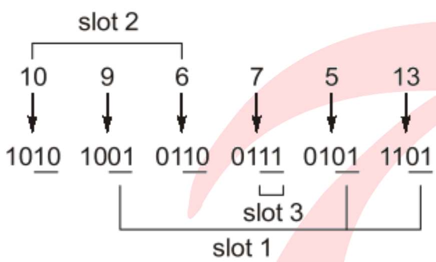


No entry for 11 in this option and 10 → has 3 entries but 2 are required.

So, option (d) is wrong. Similarly, (a), (b) options can also be proved wrong.

Option (c) is correct.

Let's check option (c).



Q.48 – Q.55 Numerical Answer Type (NAT), carry TWO mark each (no negative marks).

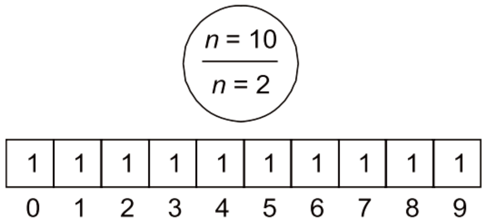
48. Consider the following ANSI C function:

```
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 $0 \le i \le 9$. The value returned by SimpleFunction(Z, 10, 2) is ________.

Ans. 1023

Exp:



SimpleFunction[Z, 10, 2]

↓

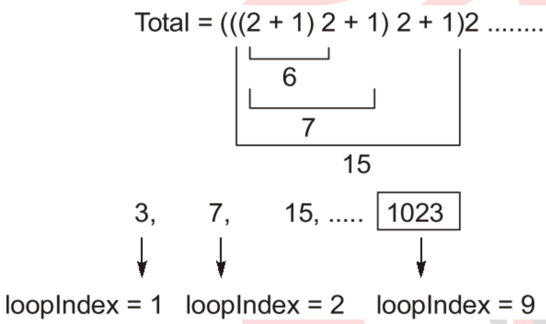
Total = 1

loopIndex = 1

↓

Total = 2 × 1 + Y[1]

= 2 + 1



49. 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 acknowledgement 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 acknowledgement 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 ________.

Ans. 50 – 52

Exp:

$T_t(\text{packet}) = \dfrac{L}{B.W}$

$\Rightarrow \qquad \dfrac{2000\,\text{bits}}{10^6\,\text{bps}} = 2\times10^{-3}\,\text{sec} = 2\,\text{milli}\,\text{sec}$

$T_t\,(\text{Ack}) = \dfrac{L}{B.W}$

$\Rightarrow \qquad \dfrac{10\,\text{bits}}{10^6\,\text{bps}} = 10^{-5}$ sec = 10^{-2} millisec = 0.01 millisec

T_p = 100 millisec

Total time = T_t (packet) + 2 × T_p + T_t (Ack)

$\Rightarrow$ 1 + 200 + 0.01 = 201.01 millisec

Efficiency = 50% = $\dfrac{useful\ time}{total\ time}$

$\dfrac{1}{2} = \dfrac{n \times T_t}{Total\ time}$

2 × n = 201.01

n = 100.5

For minimum we have to take ceil, hence size of window = 101

50. Consider the following C code segment :

a = b + c ;

e = a + 1 ;

d = b + c ;

f = d + 1 ;

g = e + f ;

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

Ans. 6

Exp:

a = b + c ;

e = a + 1 ;

d = b + c ;

f = d + 1 ;

g = e + f ;

using common sub-expression elimination this code will become.

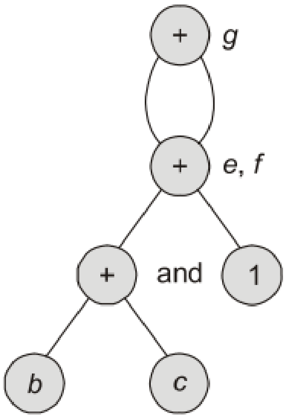
a = b + c

e = a + 1

d = a

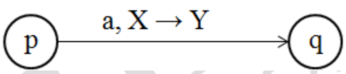
f = e

g = e + e



No. of nodes = 6

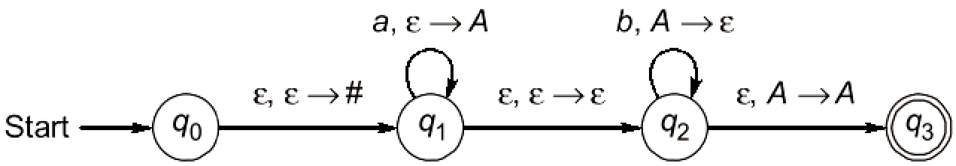
51. In a pushdown automaton P = (Q, ∑, Γ, δ, q_0, F), a transition of the form,



where p, q ϵ Q, a ϵ ∑ ∪ {ϵ}, and X, Y ϵ Γ ∪ {ϵ}, represents

(q, Y) ϵ δ(p, a, X).

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



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

Ans. 50

Exp:

The machine is pushing a "A" for every 'a' in input and popping a "A" for every 'b' in input which follows a's. No a's are allowed after the b's and also at end of input, the stack must have at least one "A" for string to be accepted, which means number of a's > number of b's.

So, language accepted is

$L = \{a^m b^n \mid m > n \geq 0\}$

Now, strings of length 100 which satisfy above condition are $\{a^{100}, a^{99}b, a^{98}b^2, \ldots, a^{51}b^{48}\}$.

Number of such strings is therefore 50.

52. 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 ________.

Ans. 3

Exp:

$$A = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

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

$C_1 \to C_1 + C_2 + C_3 + C_4$, we get

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

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

Now, $R_2 \rightarrow R_2 - R_1$, $R_3 \rightarrow R_3 - R_1$, $R_4 \rightarrow R_4 - R_1$

$$\Rightarrow \qquad (-\lambda+3)\begin{vmatrix} 1 & 1 & 1 & 1 \\ 0 & -\lambda-1 & 0 & 0 \\ 0 & 0 & -\lambda-1 & 0 \\ 0 & 0 & 0 & -\lambda-1 \end{vmatrix} = 0$$

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

$\lambda = 3, -1, -1, -1.$

So, max. Eigen value = 3

53. A five-stage pipeline has stage 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.

Ans. 17160

Exp:

K = 5

t_p = max (Stage delay + Buffer delay) = 165 ns

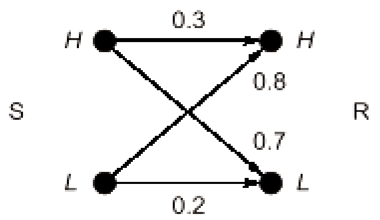
$n = 100 \underset{\downarrow}{(\mathit{finite})}$

$ET_{pipe} = (K + n - 1)\, t_p$

= (5 + 100 – 1) 165 ns = 17160 ns

54. 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 ϵ {H, L}. For example, the probability that the received signal is L given the transmitted signal was H, is 0.7.

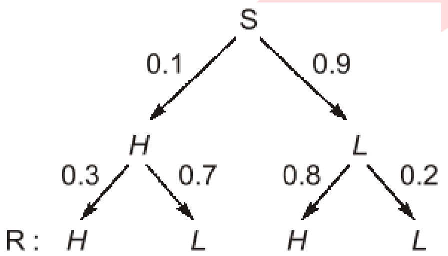


If the received signal is H, the probability that the transmitted signal was H (rounded to 2 decimal places) is ________.

Ans. 0.04

Exp:

$$P\left(\frac{H_S}{H_R}\right) = \frac{P(H_S \cap H_R)}{P(H_R)} = \frac{0.1\times 0.3}{0.1\times 0.3 + 0.9\times 0.8} = 0.04$$



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

Instruction	**Semantics**	**Instruction Size** (bytes)
MOV R1, (5000)	R1 ← MEMORY [5000]	4
MOV R2, (R3)	R2 ← MEMORY [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 ________.

Ans. 50

Exp:

Program execution 10 memory cells information is accessed for reading & writing starting from 3000 location.

So, 3000 to 3009 cells are accessed for read and write.

∴ No change in [3010] cell.

So, It contains 50 only.