GENERAL APTITUDE

Q. No. 1 - 5 Carry One Mark Each

1. The dawn of the 21st century witnessed the melting glaciers oscillating between giving too much and too little to billions of people who depend on them for fresh water. The UN climate report estimates that without deep cuts to ma-made emissions, at least 30% of the northern hemisphere's surface permafrost could melt by the end of the century. Given this situation of imminent global exodus of billions of people displaced by rising seas, nation-states need to rethink their carbon footprint for political concerns, if not for environmental ones.

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

(A) Nation-states do not have environmental concerns.

(B) Billions of people are responsible for man-made emissions.

(C) Billions of people are affected by melting glaciers.

(D) Nation-states are responsible for providing fresh water to billions of people.

Key: (C)

2. Select the word that fits the analogy:

Cook: Cook:: Fly: _____.

(A) Flyer (B) Flying (C) Flew (D) Flighter

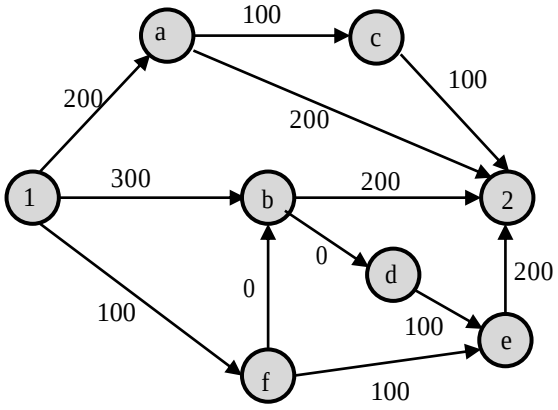
Key: (A)

3. His knowledge of the subject was excellent but his classroom performance was _____.

(A) desirable (B) extremely poor (C) praiseworthy (D) good

Key: (B)

4. There are multiple routes to reach from node 1 to node 2, as shown in the network.

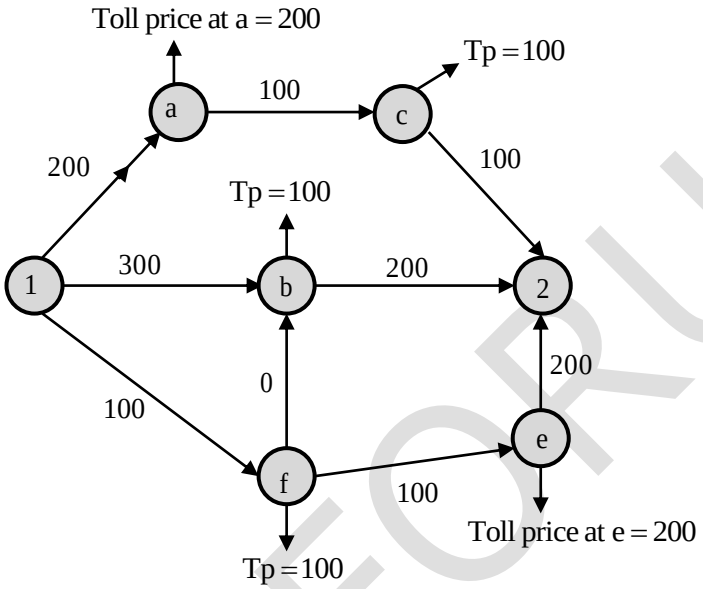


The cost of travel on an edge between two nodes is given in rupees. Node 'a', 'b', 'c', 'd', 'e' and 'f' are toll booths. The toll price at toll booths marked 'a' and 'e' is Rs. 200, and is Rs. 100 for the other toll booths. Which is the cheapest route route from node 1 to node 2?

(A) 1-f-e-2 (B) 1-b-2 (C) 1-a-c-2 (D) 1-f-b-2

Key: (D)

Sol: From the given figure, the cheapest route from node 1 to node 2 is 1-f-b-2.



(a) cost of travel of the route 1-f-e-2 is
100 + 100 + 100 + 200 + 200 =700

(b) Cost of travel of the route 1-b-2 is 300 + 100 + 200 = 600

(c) Cost of travel of the route 1-a-c-2 is 200 + 200 + 100 + 100 + 100 = 700

(d) Cost of travel of the route 1-f-b-2 is 100 + 100 + 0 + 100 + 200 = 500

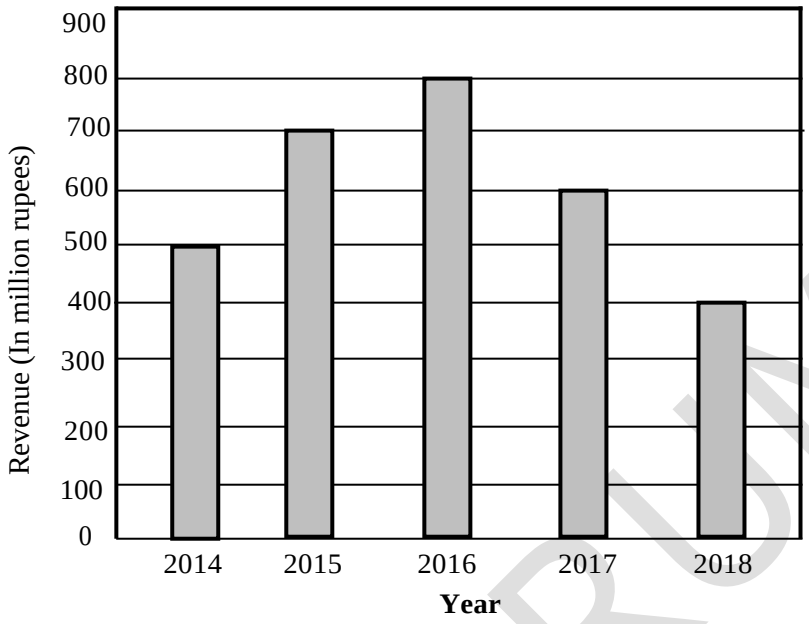
5. Raman is confident of speaking English _____ six months as he has been practising regularly _____ the last three weeks.

(A) during, for (B) within, for (C) for, in (D) for, since

Key: (B)

Q. No. 6 - 10 Carry Two Marks Each

6. The total revenue of a company during 2014-2018 is shown in the bar graph. If the total expenditure of the company in each year is 500 million rupees, then the aggregated profit or loss (in percentage) on the total expenditure of the company during 2014-2018 is _____.



(A) 20% profit (B) 20% loss (C) 16.67 % loss (D) 16.67% profit

Key: (A)

Sol: From the chart;

Revenue of a company during 2014-2018 are 500, 700, 800, 600, 400.

Total revenue = 3000 million rupees

Total expenditure of the company during 2014-2018.

= 5 × 500 million = 2500million

$$\therefore \text{Profit } \% = \frac{3000-2500}{2500}\times 100 = \frac{500}{2500}\times 100 = 20\%$$

7. Two straight lines are drawn perpendicular to each other in X-Y plane. If α and β are the acute angles the straight lines make with the X-axis, then $\alpha+\beta$ is _____.

(A) 120° (B) 60° (C) 90° (D) 180°

Key: (C)

8. Goods and Services Tax (GST) is an indirect tax introduced in India in 2017 that is imposed on the supply of goods and services, and it subsumes all indirect taxes except few. It is a destination-based tax imposed on goods and services used, and it is not imposed at the point of origin from where goods come. GST also has a few components specific to state governments, central government and Union Territories (UTs).

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

(A) GST is imposed at the point of usage of goods and services.

(B) GST does not have a component specific to UT.

(C) GST includes all indirect taxes.

(D) GST in imposed on the production of goods and services.

Key: (A)

9. If P = 3, R = 27, T = 243, then Q + S = _____.

(A) 40 (B) 110 (C) 90 (D) 80

Key: (C)

Sol:

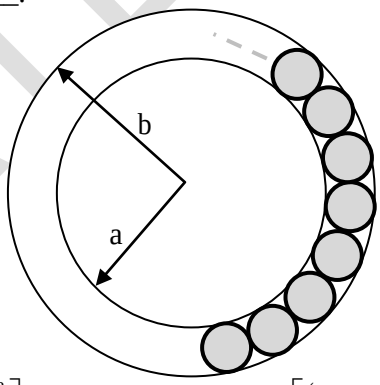
P	Q	R	S	T
3		27		243
3^1		3^3		3^5
	3^2		3^4	

$\therefore \quad Q = 3^2 = 9$

$S = 3^4 = 81$

$\therefore \quad Q + S = 90$

10. The figure below shows an annular right with outer and inner radii as b and a, respectively. The annular space has been painted in the form of blue colour circles touching the outer and inner periphery of annular space. If maximum n number of circles can be painted, then the unpainted area available in annual space is _____.

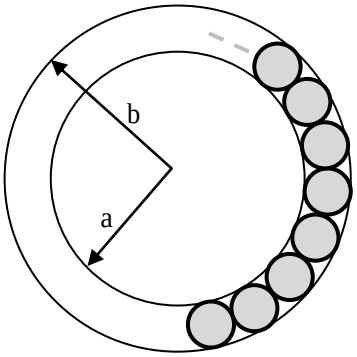


(A) $\pi\left[\left(b^2 - a^2\right) - n\left(b - a\right)^2\right]$ (B) $\pi\left[\left(b^2 - a^2\right) + n\left(b - a\right)^2\right]$

(C) $\pi\left[\left(b^2 - a^2\right) - \frac{n}{4}\left(b - a\right)^2\right]$ (D) $\pi\left[\left(b^2 - a^2\right) + \frac{n}{4}\left(b - a\right)^2\right]$

Key: (C)

Sol: Given figure is



The annular space is the area between the circles.

$\therefore$ Area of annular space = outer circle area – inner circle area $= \pi b^2 - \pi a^2$

Radius of blue color $= \frac{b-a}{2}$

Area of blue colour circle $= \pi\left(\frac{b-a}{2}\right)^2 = \frac{\pi(b-a)^2}{4}$

Total area of such 'n' blue colour circles $= n\pi\frac{(b-a)^2}{4}$

$\therefore$ Unpainted area available in annular space = annualar space area $- \frac{n\pi(b-a)^2}{4}$

$= \pi\left[\left(b^2 - a^2\right) - \frac{n}{4}(b-a)^2\right]$

COMPUTER SCIENCE ENGINEERING

Q. No. 1 to 25 Carry One Mark Each

1. Consider the following grammar.

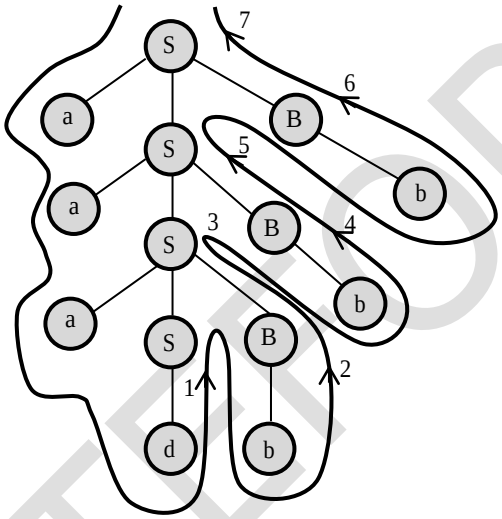
$S \rightarrow aSB \mid d$

$B \rightarrow b$

The number of reduction steps taken by a bottom-up parser while accepting the string *aaadbbb* is _____.

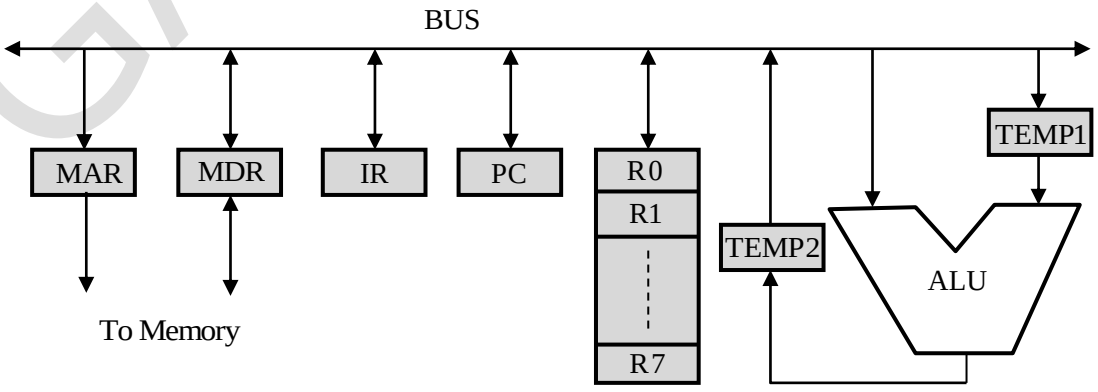
Key: (7)

Sol:



Total 7 reduction steps.

2. Consider the following data path diagram.



Consider an instruction: $R0 \leftarrow R1 + R2$. The following steps are used to execute it over the given data path. Assume that PC is incremented appropriately. The subscripts r and w indicate read and write operations, respectively.

1. $R2_r, TEMP1_r, ALU_{add}, TEMP2_w$

2. $R1_r, TEMP1_w$

3. PC_r, MAR_w, MEM_r

4. $TEMP2_r, R0_w$

5. MDR_r, IR_w

Which one of the following is the correct order of execution of the above steps?

(A) 3, 5, 2, 1, 4 (B) 2, 1, 4, 5, 3 (C) 3, 5, 1, 2, 4 (D) 1, 2, 4, 3, 5

Key: (A)

Sol: The correct order of execution:

3. $PC_r, MAR_{W,} MEM_r$

5. MDR_r, IR_W

2. $R1_r, TEMP1_W$

1. $R2_r, TEMP1_{r,} ALU_{add}, TEMP2_W$

4. $TEMP2_r, RO_W$.

3. Consider allocation of memory to a new process. Assume that one of the existing holes in the memory will exactly fit the process's memory requirement. Hence, a new hole of smaller size will be created if allocation is made in any of the existing holes. Which one of the following statements is TRUE?

(A) The hole created by next fit is never larger than the hole created by best fit.

(B) The hole created by best fit is never larger than the hole created by first fit.

(C) The hole created by first fit is always large than the hole created by next fit.

(D) The hole created by worst fit is always larger than the hole created by first fit.

Key: (B)

Sol: Given that, "none of the existing holes in the memory will exactly fit the process's memory requirement. Hence, a new hole of smaller size will be created if allocation is made in any of the existing holes".

As best fit always chooses "the smallest hole that is big enough". The hole created by best fit is never larger than the hole created by first fit. Hence option (B) is correct.

Option C and D are not "always" possible.

4. Which one of the following regular expressions represents the set of all binary strings with an odd number of 1's?

(A) ((0 +1)*1(0+1)*1)*10*

(B) (0*10*10*)*10*

(C) 10*(0*10*10*)*

(D) (0*10*10*)*0*1

Key: (B)

Sol: (A) never generate 10.

(B) never generate 01.

(C) never generate 10.

(D) generate all binary string with odd number of 1's.

5. For parameter a and b, both of which are $\omega(1), T(n) = T\left(n^{1/a}\right) + 1$, and T(b) = 1

Then T(n) is

(A) $\Theta(\log_{ab} n)$

(B) $\Theta(\log_a \log_b n)$

(C) $\Theta(\log_b \log_a n)$

(D) $\Theta(\log_2 \log_2 n)$

Key: (B)

Sol: $T(n) = T\left(n^{1/a}\right) + 1$

Using substitution method

$T(n) = T\left(n^{1/a^2}\right) + 2$

$T(n) = T\left(n^{1/a^3}\right) + 3$

$\vdots$

$T(n) = T\left(n^{1/a^k}\right) + k$

$\text{Let}, n^{1/a^k} = b \Rightarrow a^k = \log_b n$

$k = \log_a \log_b n$

$T(n) = T(b) + \log_a \log_b n$

$\therefore T(n) = 1 + \log_a \log_b n$

6. Consider the language $L = \{a^n \mid n \geq 0\} \cup (a^n b^n \mid n \geq 0)$ and the following statements.

I. L is deterministic context-free.

II. L is context-free but not deterministic context-free.

III. L is not LL(k) for any k.

Which of the above statements is/are TRUE?

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

Key: (D)

Sol: L is DCFL because we can design DPDA for L.

The grammar for L is

$S \rightarrow aSb \mid A$

$A \rightarrow aA \mid \in$

Not LL(1) because there is indirect left factoring.

7. Consider the following statements about the functionality of an IP based router.

I. A router does not modify the IP packets during forwarding.

II. It is not necessary for a router to implement any routing protocol.

III. A router should reassemble IP fragments if the MTU of the outgoing link is larger than the size of the incoming IP packet.

Which of the above statements is/are TRUE?

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

Key: (A)

Sol: S_1 is FALSE as router decrements TTL value of IP Packet during forwarding.

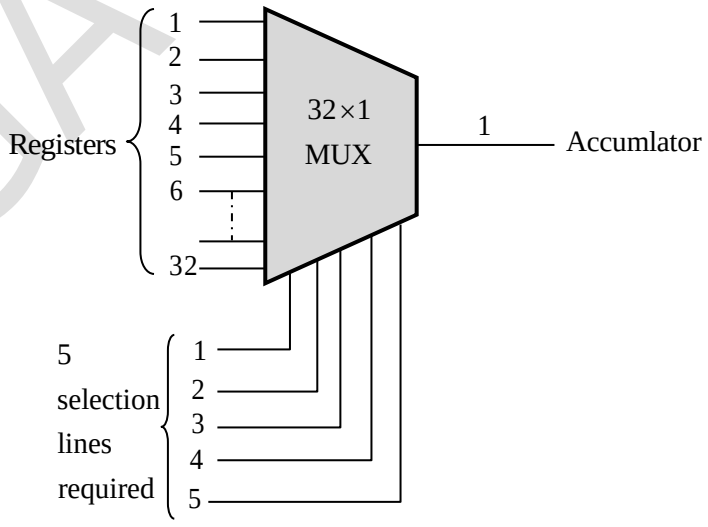
S_3 is FALSE, as the MTU of the outgoing link is larger than the size of the incoming IP packet, router does not require reassemble IP fragments.

S_2 is TRUE, it is not necessary for a router to implement routing protocol.

8. A multiplexer is placed between a group of 32 registers and an accumulator to regulate data movement such that at any given point in time the content of only one register will move to the accumulator. The minimum number of select lines needed for the multiplexer is _____.

Key: (5)

Sol:



9. Consider the functions.

I. e^{-x}

II. $x^2 - \sin x$

III. $\sqrt{x^3+1}$

Which of the above function is/are increasing everywhere in [0, 1]?

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

Key: (B)

Sol: I. e^{-x} is growth decreasing function.

II. $x^2 - \sin x$ is growth decreasing function.

III $\sqrt{x^3+1}$ is growth increasing function.

10. A direct mapped cache memory of 1 MB has a block size of 256 bytes. The cache has an access time of 3 ns and a hit rate of 94%. During a cache miss, it takes 20 ns to bring the first word of a block from the main memory, while each subsequent word takes 5 ns. The word size is 64 bits. The average memory access time in ns (round off to 1 decimal place) is _____.

Key: (13.32)

Sol: Block size = 256 byte, word size = 64 bit = 8byte.

So, we need to send 32 words (i.e. one block) from memory when there is miss in cache.

$$EAT = \left(0.94*3 + 0.06\left(1*20 + 31*5\right)\right) \text{ns}$$
$$= 2.88 + 10.5 = 13.32\text{ns}$$

11. Let G be a group of 35 elements. Then the largest possible size of a subgroup of G other than G itself is _____.

Key: (7)

Sol: Order of given group =35 and the order of sub group always divides the order of group.

So possible order of subgroup is 1, 5, 7, 35 it self group.

So largest proper. sub group is "7"

12. Consider the following statements.

I. Symbol table is accessed only during lexical analysis and syntax analysis.

II. Compilers for programming languages that support recursion necessarily need heap storage for memory allocation in the run-time environment.

III. Errors violating the condition '*any variable must be declared before its use*'are detected during syntax analysis.

Which of the above statement is/are TRUE?

(A) I and III only (B) I only

(C) None of I, II, and III (D) II only

Key: (C)

Sol: I. False: we can access symbol table in all the phases.

II. False: we can use stack data structure.

III. False: will be identified in semantic analysis phase of the compiler.

13. Consider the following statements.

I. If $L_1 \cup L_2$ is regular, then both L_1 and L_2 must be regular.

II. The class regular languages is closed under infinite union.

Which of the above statements is/are TRUE?

(A) II only (B) Both I and II

(C) Neither I nor II (D) I only

Key: (C)

Sol: $L_1 = a^*b^*$ R.L.

$L_2 = a^n b^n \mid n \geq 0$ CF.L

$L_1 \cup L_2 = a^*b^*$ Regular

So (I) is false.

(II) is also false because regular languages are not closed under infinite inter section.

14. Which of the following is used to represent the supporting many-one relationships of a weak entity set in an entity-relationship diagram?

(A) Ovals that contain underlined identifiers

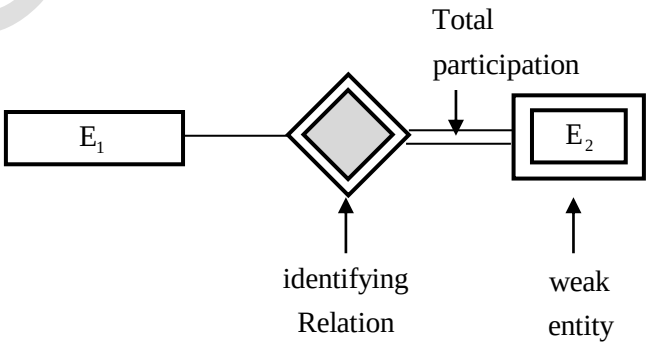
(B) Rectangles with double/bold border

(C) Diamonds with double/bold border

(D) Ovals with double/bold border

Key: (C)

Sol:



15. If there are m input lines and n output lines for a decoder that is used to uniquely address a byte addressable 1KB RAM, then the minimum value of $m + n$ is _____.

Key: (1034)

Sol: We require 2^{10} outputs to map 1KB RAM.

So, we need 10×2^{10} decoder

$x = 10$ & $y = 2^{10}$

$x + y = 1034$.

16. Consider a relational database containing the following schemas.

Catalogue

sno	pno	cost
S1	P1	150
S1	P2	50
S1	P3	100
S2	P4	200
S2	P5	250
S3	P1	250
S3	P2	150
S3	P5	300
S3	P4	250

Suppliers

sno	sname	location
S1	M/s Royal furniture	Delhi
S2	M/s Balaji furniture	Bangalore
S3	M/s Premium furniture	Chennai

Parts

pno	pname	part_spec
P1	Table	Wood
P2	Chair	Wood
P3	Table	Steel
P4	Almirah	Steel
P5	Almirah	Wood

The primary key of each table is indicated by underlining the constituent fields.

```
SELECT    s.sno,  s.sname
FROM      Suppliers s, Catalogue c
WHERE     s.sno = c.sno AND
          cost > (SELET AVG (cost)
                  FROM Catalouge
                  WHERE pno = 'P4'
                  GROUP BY pno);
```

The number of rows returned by the above SQL query is

(A) 2 (B) 5 (C) 4 (D) 0

Key: (C)

Sol: Output

Sno	Sname
S_1	RF
S_2	BF
S_3	PF
S_3	PF

Total 4 tuple print.

The number of rows returned by the above SQL query is 4.

17. What is the worst case time complexity of inserting n^2 elements into an AVL-tree with n elements initially?

(A) $\Theta(n^3)$ (B) $\Theta(n^2 \log n)$ (C) $\Theta(n^2)$ (D) $\Theta(n^4)$

Key: (B)

Sol: $O(n^2 \log n)$

To insert one element

$\rightarrow$ (1) Find position (log n)

$\rightarrow$ (2) Insert item(log n)

So, $2\log n \cong \log n$

To insert n^2 element time complexity is $\theta(n^2 \log n)$.

18. The preorder traversal of a binary search tree is 15, 10, 12, 11, 20, 18, 16, 19.

Which one of the following is the postorder traversal of the tree?

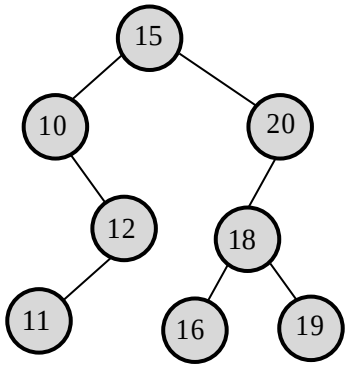
(A) 10, 11, 12, 15, 16, 18, 19, 20 (B) 20, 19, 18, 16, 15, 12, 11, 10

(C) 19, 16, 18, 20, 11, 12, 10, 15 (D) 11, 12, 10, 16, 19, 18, 20, 15

Key: (D)

Sol: Pre order 15, 10, 12, 11, 20, 18, 16, 19.

So, BST is



Post order: 11 12 10 16 19 18 20 15.

19. What is the worst case time complexity of inserting *n* elements into an empty linked list, if the linked list needs to be maintained in sorted order?

(A) $\Theta(n)$ (B) $\Theta(1)$ (C) $\Theta(n^2)$ (D) $\Theta(n\log n)$

Key: (D)

Sol: 1st sort the n elements using merge sort so the complexity merge sort in worst case is $\theta(n\log n)$

Now insert the element in link list using insert at first so time required for insertion $=\theta$

Total time $=\theta(n\log n)+\theta(n)=\theta(n\log n)$

20. Let R be the set of all binary relations on the set [1, 2, 3]. Suppose a relation is chosen from R at random. The probability that the chosen relation is reflexive (round off to 3 decimal places) is _____.

Key: (0.125)

Sol: $A\{1,2,3\}$

Total number of relation on $A=2^{n^2}=2^{3^2}\Rightarrow 2^9=512$

Number of reflexive relation on $A=2^{3^2-3}=2^6=64$

$$P[\text{reflexive}]=\frac{64}{512}=0.125$$

21. Consider the following statements.

I. Daisy chaining is used to assign priorities in attending interrupts.

II. When a device raises a vectored interrupt, the CPU does polling to identify the source of interrupt.

III. In polling, the CPU periodically checks the status bits to know if any device needs its attention.

IV. During DMA, both the CPU and DMA controller can be bus masters at the same time.

Which of the above statements is/are TRUE?

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

Key: (C)

Sol: Daisy chaining use priority and polling uses status bit to resolve interrupt.

22. Consider the following C program.

```
# include <stdio. h>
int main ( ){
    int a[4][5] =   {1, 2, 3, 4, 5},
                    {6, 7, 8, 9, 10},
                    {11, 12, 13, 14, 15},
                    {16, 17, 18, 19, 20}};
    printf("%d\n", *(*a+**a+ 2)+3));
    return (0);
}
```

The output of the program is _____.

Key: (19)

Sol: $\Rightarrow *(*(a+**a+2)+3)$

$\Rightarrow *(*(a+1+2)+3)$

$\Rightarrow *(*(a+3)+3)$

Address of 3^{rd} column of 3^{rd} row

$\Rightarrow 19$

23. Consider the following statements about process state transitions for a system using preemptive scheduling.

I. A running process can move to ready state.

II. A ready process can move to running state.

III. A blocked process can move to running state.

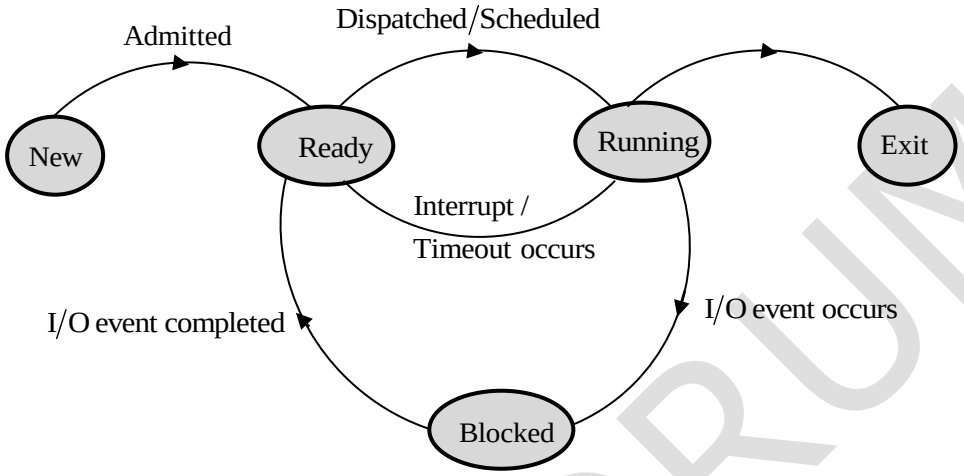
IV. A blocked process can move to ready state.

Which of the above statements are TRUE?

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

Key: (D)

Sol: Process state diagram for a preemptive scheduling OS is as follows:



So,

A process can make a transition from ready state to running state.

A process can make a transition from running state to ready state.

A process can make a transition from blocked state to ready state.

But a process cannot make a transition from blocked state to running state.

Hence, option (D) is correct.

24. Assume that you have made a request for a web page through your web browser to a web server. Initially the browser cache is empty. Further, the browser is configured to send HTTP requests in non-persistent mode. The web pages contains text an five very small images. The minimum number of TCP connections required to display the web page completely in your browser is _____.

Key: (6)

Sol: HTTP can use the following 2 types of connections. They are

(i) Persistant

(ii) Non Persistant

(i) In HTTP with non persistant connection, each TCP connection transports exactly one request/response message.

(ii) In HTTP with persistant correction, each TCP connection load and receive multiple requests/responses. By default, HTTP uses persistant connections rather than non persistant.

(iii) As per question, web page with non persistant HTTP connection, has one text and 5 small size images. So, for text image one TCP connection is required and for 5 small images, 5 TCP

connections are required. Hence, to transfer one text and 5 small size images, the number of TCP connections required is 6.

25. Consider a double hashing scheme in which the primary has function is $h_1(k) = k \bmod 23$, and the secondary hash function is $h_2(k) = 1 + (k \bmod 19)$. Assume that the table size is 23. Then the address returned by probe 1 in the probe sequence (assume that the probe sequence begins at probe 0) for key value k = 90 is _____.

Key: (13)

Sol: K=90

Using first Hash function

$h_1(90) = 90 \bmod 23$

$h_1(90) = 21$

If there is collision at probe O, then search for prob 1.

So, pass key 90 by Hash function (2)

$h_2(90) = 1 + (90 \bmod 19)$

$= 1 + 14 \Rightarrow 15$

So address is $\Rightarrow 21 + 15 = 36$

The address returned by probe 1 in the probe sequence for key value k = 90 is 36 mod 23 = 13

Q. No. 26 to 55 Carry Two Marks Each

26. Which one of the following predicate formulae is NOT logically valid?

Note that W is a predicate formula without any free occurrence of x.

(A) $\exists x(p(x) \to W) \equiv \forall x p(x) \to W$

(B) $\forall x(p(x) \to W) \equiv \forall x p(x) \to W$

(C) $\forall x(p(x) \vee W) = \forall x p(x) \vee W$

(D) $\exists x(p(x) \wedge W) = \exists x p(x) \wedge W$

Key: (B)

Sol: $\forall x(p(x) \to W) = \forall x p(x) \to W$

Wrong because,

$\forall x(px \to W)$

$\forall x(\sim p(x) \vee W)$

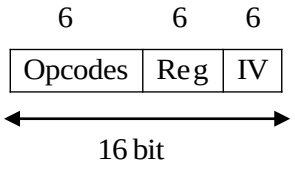
$\Rightarrow \sim(\exists x\, p(x)) \vee W$

$\Rightarrow \exists x\, p(x) \to W$

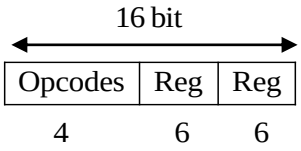
27. A processor has 64 registers and uses 16-bit instruction format. It has two types of instructions: I –type and R-type. Each I-type instruction contains an opcode, a register name, and a 4-bit immediate value. Each R-type instruction contains an opcode and two register names. If there are 8 distinct I-type opcodes, then the maximum number of distinct R-type opcodes is _____.

Key: (14)

Sol: I-type



R-type



Number of operations possible $= 2^4 = 16$ suppose x R type inst^n possible, then number of remaining opcodes $= 16 - x$

Number of I-type instructions possible $= (16 - x) * 2^2$

$\Rightarrow 8 = 64 - 4x$

$\therefore x = 14$

28. An organization requires a range of IP addresses to assign one to each of its 1500 computers. The organization has approached an Internet Service Provider (ISP) for this task. The ISP uses CIDR and serves the requests from the available IP address space 202.61.0.0/17. The ISP wants to assign an address space to the organization which will minimize the number of routing entries in the ISP's router using route aggregation. Which of the following address spaces are potential candidates from which the ISP can allot one to the organization?

I. 202.61.84.0/21

II. 202.61.104.0/21

III. 202.61.64.0/21

IV. 202.61.144.0/21

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

Key: (D)

Sol: As per question, Organization requires a range of IP addresses to assign one to each of its 1500 computers.

$\Rightarrow 2^{32-n} = 1500 \approx 2^{11} \Rightarrow n = 21$

Given CIDR based address is 202.61.0.0/17

FA : 202.61.00000 000.0000 0000 | 21
LA : 202.61.00000 111.11111111 | 21

1st range of address as 256 [Means that, 202.61.0.0 | 21 to 202.61.7.255 | 21]

2nd range of address as 256
FA : 202.61.00001 000.0000 0000 | 21
LA : 202.61.00001111.11111111 | 21

$\Rightarrow$ 202.61.8.0 | 21 to 202.61.15.255 | 21

3rd range of address as 256
FA : 202.61.0001 0000.0000 0000 | 21
LA : 202.61.0001 0111.11111111 | 21

$\Rightarrow$ 202.61.16.0 | 21 to 202.61.23.255 | 21

If we look at the first address of each range of addresses:

The sequence is 0, 8, 16, 24, 32, 40, 48, 56, 64, 72, 80, 88, 96, 104, 112, 120.

Hence, option (D) is correct.

29. Consider a relational table R that is in 3NF, but not in BCNF. Which of the following statements is TRUE?

(A) R has a nontrivial functional dependency $X \rightarrow A$, Where X is not a superkey and A is a non-prime attribute and X is not a proper subset of any key.

(B) R has a nontrivial functional dependency $X \rightarrow A$, where X is not a superkey and A is a non-prime attribute and X is a proper subset of some key.

(C) R has a nontrivial functional dependency $X \rightarrow A$, where X is not a superkey and A is a prime attribute.

(D) A cell in R holds a set instead of an atomic value.

Key: (C)

Sol: If $\alpha \rightarrow \beta$ and β is prime attribute then relation is in 3NF but not in BCNF.

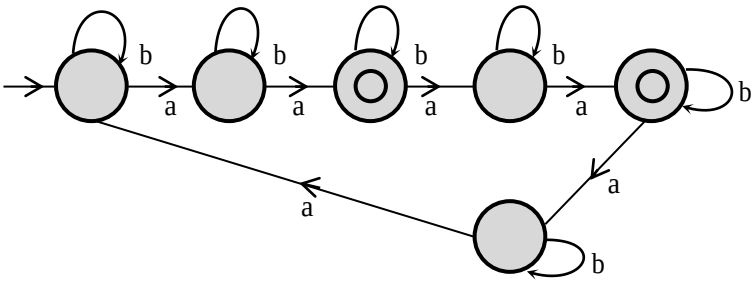
30. Consider the following language.

$L = \{x \in \{a,b\}^* |$ number of $a's$ in x is divisible by 2 but not divisible by 3$\}$

The minimum number states in a DFA that accepts L is _____.

Key: (6)

Sol:



31. Consider a database implemented using B+ tree for file indexing and installed on a disk drive with block size of 4 KB. The size of search key is 12 bytes and the size of tree/disk pointer is 8 bytes. Assume that the database has one million records. Also assume that no node of the B+ tree and no records are present initially in main memory. Consider that each record fits into one disk block. The minimum number of disk accesses required to retrieve any record in the database is _____.

Key: (4)

Sol: Block size = 4KB

Key size = 12byte

block pointer size = 8byte

Order of B^+ tree = n

$(n-1)$key + n * block pointer $\le$ B.S

$(n-1)*12 + n*8 \le 4096$

$20n \le 4108$

$n \le 205.4$

$n = 205$

To represent index of 1 million records we need B^+ tree of height $3(\text{if } n = 205)$.

So, to access record we should go up to leaf node pulse one block access to read data.

Hence, 3H=4 block access.

32. Consider three registers R1, R2 and R3 that store numbers in IEEE-754 single precision floating point format. Assume that R1 and R2 contain the values (in hexadecimal notation) 0×42200000 and 0×C1200000, respectively.

If $R3 = \frac{R1}{R2}$, what is the value stored in R3?

(A) 0×C0800000 (B) 0×40800000 (C) 0×83400000 (D) 0×C8500000

Key: (A)

Sol:

1	8	23
sign	exponent	Mantissa

$R_1 =$ | 0 | 10000100 | 010 00.....0 |

4 2 2 0 0 0 0 0

$= 1.010 * 2^{132-127}$

$= 1.010 * 2^5 \Rightarrow 101000$

$R_1 = 40\,(\text{Decimal})$

C 1 2 0 0 0 0 0

$R_2 =$ | 1 | 10000010 | 010 000.....0 |

$= 1.010 * 2^{130-127}$

$= 1.010 * 2^3 = 1010 \Rightarrow 10$

$-$ve so $R_2 = -10$

So $R_3 = \dfrac{R_1}{R_2} = \dfrac{40}{-10} = -4$

$-4 \Rightarrow 1.00 * 2^2$ → Biased by excess 127.So, $127 + 2 = 129$.

$R_3 \Rightarrow$ | 1 | 10000001 | 0000.....0 |

C 0 8 0 0 0 0 0

33. Consider a schedule of transaction T_1 and T_2 :

T_1	RA			RC		WD		WB	Commit	
T_2		RB	WB		RD		WC			Commit

Here, RX stands for "Read(X)" and WX stands for "Write(X)". Which one of the following schedules is conflict equivalent to the above schedule?

(A)

T_1	RA	RC	WD				WB		Commit	
T_2				RB	WB	RD		WC		Commit

(B)

T_1					RA	RC	WD	WB	Commit	
T_2	RB	WB	RD	WC						Commit

(C)

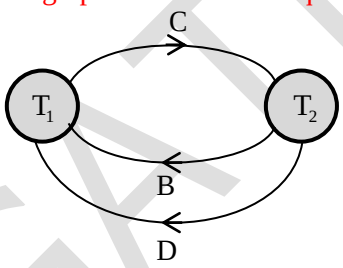
T_1				RA	RC	WD	WB		Commit	
T_2	RB	WB	RD					WC		Commit

(D)

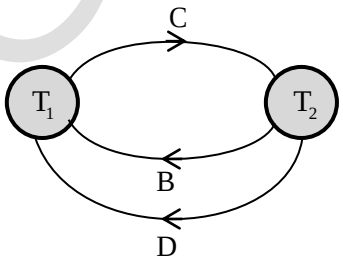
T_1	RA	RC	WD	WB					Commit	
T_2					RB	WB	RD	WC		Commit

Key: (C)

Sol: Precedence graph for schedule in question is:



Precedence graph for option (C) is



Both are same so option (C) is true.

34. Consider a paging system that uses 1-level page table residing in main memory and a TLB for address translation. Each main memory access takes 100 ns and TLB lookup takes 20 ns. Each page transfer to/from the disk takes 5000 ns. Assume that the TLB hit ratio is 95%, page fault rate is 10%. Assume that for 20% of the total page faults, a dirty page has to be written back to back to disk before the required page is read in from disk. TLB update time is negligible. The average memory access time in ns (round off to 1 decimal places) is _____.

Key: (154.5)

Sol: $EMAT = 0.95\times(20+100)+0.05\times(0.9\times(20+100+100))$

$+0.1\times(0.2\times(20+100+5000+5000)+0.8\times(20+100+5000))=154.5ns$

35. Let A and B two n × n matrices over real numbers. Let rank(M) and det (M) denote the rank and determinant of a matrix M, respectively. Consider the following statements.

I. rank(AB) = rank (A) rank (B)

II. det(AB) = det(A) det(B)

III. rank(A + B) ≤ rank (A) + rank (B)

IV. det(A + B) ≤ det(A) + det(B)

Which of the above statements are TRUE?

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

Key: (B)

Sol: From determinant properties; we have

$\det(AB)=\det(A).\det(B)$ if A, B are both square matrices of order 'n'.

So, II is correct.

From rank properties, we have

$\text{rank}(A+B)\le\text{rank}(A)+\text{rank}(B)$

So, III is correct.

36. Consider the following C function.

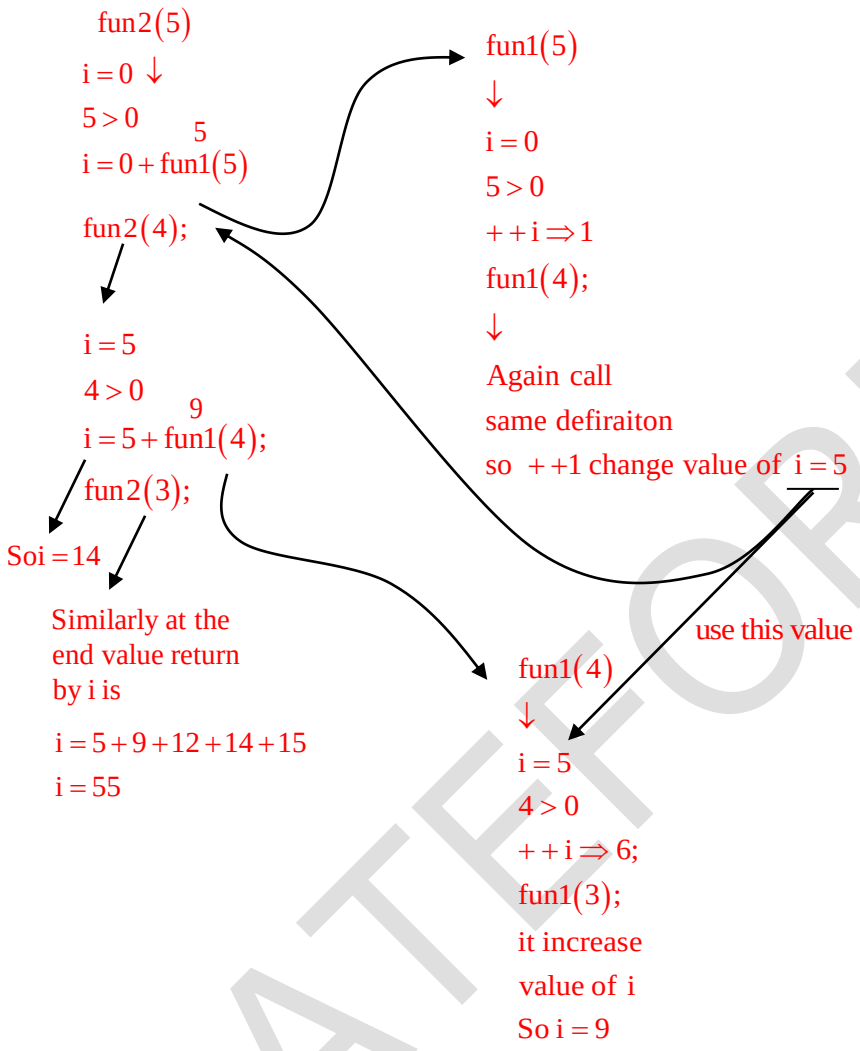
```
int fun1(int n) {
    static int i = 0;
    if (n > 0) {
        + + i;
        fun1(n-1);
    }
    return (i);
}
```

```
int fun2(int n) {
    static int i = 0
    if (n > 0) {
        i = i + fun1 (n);
        fun 2(n -1);
    }
    return (i);
}
```

The return value of `fun2(5)` is _____.

Key: (55)

Sol:



37. The number of permutations of the characters in LILAC so that no character appears in its original position, if the two L's are indistinguishable, is _____.

Key: (12)

Sol: Number of derangements

L's can be arranged in ${}^3C_2$ ways.

For each of these cases remaining 3 letters can be deranged in $2*2!$ ways

So total derangements $= {}^3C_2 * 2 * 2! = 12$

38. Consider the following languages:

$L_1 = \{wxyx \mid w, x, y \in (0+1)^+\}$

$L_2 = \{xy \mid x, y \in (a+b)^*, |x| = |y|, x \neq y\}$

Which of the of the following is TRUE?

(A) L_1 is regular and L_2 is context-free.

(B) L_1 is context-free but L_2 is not context-free.

(C) Neither L_1 nor L_2 is context-free.

(D) L_1 is context-free but not regular and L_2 is context-free.

Key: (A)

Sol: Regular expression for L_1.

$L_1 = (0+1)^+ 0(0+1)^+ 0(0+1)^+ + (0+1)^+ 1(0+1)^+ 1(0+1)^+$

So L_1 is regular.

We need to remember length of x & y so we need memory (stack) so it is not regular but CFL.

39. Consider the productions $A \to PQ$ and $A \to XY$. Each of the five non-terminals A, P, Q, X and Y has two attributes: s is a synthesized attribute, and i is an inherited attribute. Consider the following rules.

Rule 1: P.i = A.i + 2Q.i = P.i+ A.i and A.s = P.s+ Q.s

Rule 2: X.i = A.i+ Y.s and Y.i = X.s+ A.i

Which one of the following is TRUE?

(A) Both Rule 1 and Rule 2 are L-attributed.

(B) Only Rule 1 is L-attributed.

(C) Only Rule 2 is L-attributed.

(D) Neither Rule 1 nor Rule 2 is L-attributed.

Key: (B)

Sol: Only Rule 1 is L attributed

Rule1: $\left.\begin{array}{l} P.i = A.i + 2, \\ Q.i = p.i + A.i \\ A.s = p.s + Q.s \end{array}\right\}$ L Attributed

Rule 2: X.i = A.i + y.i

→ X depends on right child so it is not L Attributed

y.i = x.s + A.i child so it is not L attributed

40. Let G = (V, E) be a directed, weighted graph with weight function $w : E \to \mathbb{R}$.

For some function $f : V \to \mathbb{R}$, for each edge $(u, v) \in E$, define $w'(u, v)$ as $w(u, v) + f(u) - f(v)$.

Which one of the options completes the following sentence so that it is TRUE?

"The shortest paths in G under w are shortest paths under w' too, _____".

(A) if and only if f(u) is the distance from s to u in the graph obtained by adding a new vertex s to G and edges of zero weight from s to every vertex of G

(B) for every $f : V \to \mathbb{R}$

(C) if and only if $\forall u \in V$, f(u) is positive

(D) if and only if $\forall u \in V$, f(u) is negative

Key: (B)

Sol: Option A is false because of "if and only if" point. Condition is option A is sufficient but not necessary condition for shortest path not to change.

Option B is correct because in every path, all the f values of intermediate vertices will cancel each other in the summation of edges on that path except for first (source) and last (destination) vertices. In every path from vertex u to v, f(u) - f(v) will be added to the that path length. So, the shortest path will not change.

41. Let G = (V, E) be a weighted undirected graph and let T be a Minimum Spanning Tree (MST) of G maintained using adjacency lists. Suppose a new weighted edge $(u, v) \in V \times V$ is added to G. The worstcase time complexity of determining if T is still an MST of the resultant graph is

(A) $\Theta(|E||V|)$ (B) $\Theta(|E|\log|V|)$ (C) $\Theta(|V|)$ (D) $\Theta(|E|+|V|)$

Key: (C)

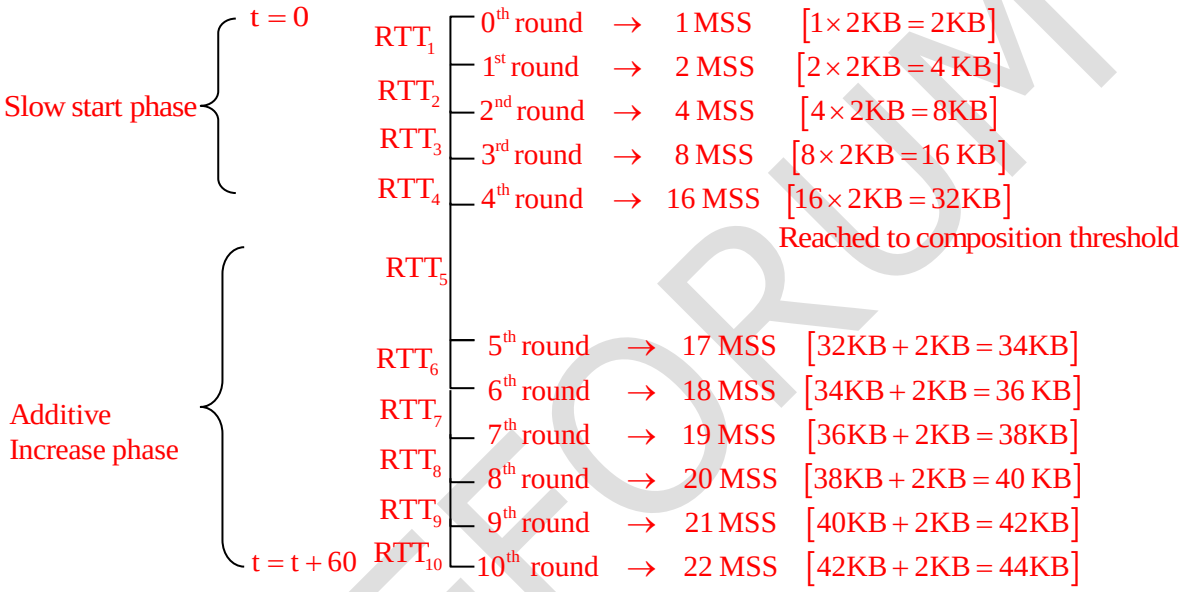
Sol: in MST , we have n vertices and n-1 edges so when we add new edge in graph G, we need to check whether that new edge will be present in modified MST or not, and for that edge to occur in modified MST, that edge should make a cycle with the original edges of MST and in that cycle that edge must not be largest weight. Since we are checking for cycles in MST and not in the graph G, time taken will be V+E where E is V-1. So final time is order of V only.

42. Consider a TCP connection between a client and a server with the following specification the round trip time is 6 ms, the size of the receiver advertised window is 50 KB, slow-start threshold at the client is 32 KB, and the maximum segment size is 2 KB. The connection is established at time t = 0. Assume that there are no timeouts and errors during transmission. Then the size of the congestion window (in KB) at time t + 60 ms after all acknowledgements are processed is _____.

Key: (44)

Sol: Given that $MSS = 2kB$

$Threshold = 32\ kB$



At t = 0, the congestion window is started with 1 MSS.

At t + 60, the congestion window is size is reached 44kB.

43. A computer system with a word length of 32 bits has a 16 MB byte-addressable main memory and a 64 KB, 4-way set associative cache memory with a block size of 256 bytes. Consider the following four physical addresses represented in hexadecimal notation.

$A1 = 0 \times 42C8A4$

$A2 = 0 \times 546888$

$A3 = 0 \times 6A289C$

$A4 = 0 \times 5E4880$

Which one of the following is TRUE?

(A) A1 and A4 are mapped to different cache sets.

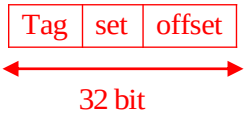
(B) A2 and A3 are mapped to the same cache set.

(C) A3 and A4 are mapped to the same cache set.

(D) A1 and A3 are mapped to the same cache set.

Key: (B)

Sol: 18 16 8



$\text{Block size} = 256 \Rightarrow 2^8 \rightarrow \text{offset}$

$$\text{Set Number} = \frac{\text{cache size}}{\text{Block size} * \text{Number of ways}}$$

$$= \frac{64KB}{256 * 4}$$

$$= \frac{2^{16}}{2^8 * 2^2} = 2^6 \Rightarrow \text{set No.}$$

$\text{Tag} = 32 - (6+8)$

Now $A_1 = 42C8A4$

$= 0100\ 0010\ 1100\ 1000\ 10100100$

Set No

$A_2 = 546888$

$= 0101\ 0100\ 0110\ 1000\ 1000\ 1000$

Set No

Same

$A_3 = 6A289C$

SetNo

$= 0110\ 1010\ 0010\ 1000\ 1001\ 1100$

So A_2 & A_3 set Numbers are same.

44. Which of the following languages are undecidable? Note that $\langle M \rangle$ indicates encoding of the Turing machine M.

$L_1 = \{\langle M \rangle \mid L(M) = \phi\}$

$L_2 = \{\langle M, w, q \rangle \mid M \text{ on input w reaches state q in exactly } 100 \text{ steps}\}$

$L_3 = \{\langle M \rangle \mid L(M) \text{ is not recursive}\}$

$L_4 = \{\langle M \rangle \mid L(M) \text{contains at least 21 members}\}$

(A) L_1, L_3 and L_4 only

(B) L_2, L_3 and L_4only

(C) L_2 and L_3 only

(D) L_1 and L_3 only

Key: **(A)**

Sol: L_1 : Emptiness problem of TM is undividable.

L_2 : Decidable after 100 steps TM will halt for both the valid/invalid input.

L_3 : It is undecidable.

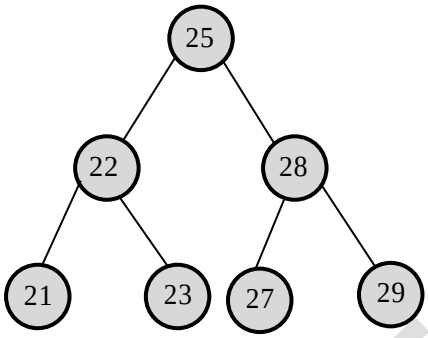
L_3 : Membership problem of TM is undecidable.

45. In a balanced binary search tree with n elements, what is the worst case time complexity of reporting all elementsin range [a, b]? Assume that the number of reported elements is k.

(A) $\Theta(k \log n)$ (B) $\Theta(\log n + k)$ (C) $\Theta(n \log k)$ (D) $\Theta(\log n)$

Key: **(B)**

Sol:



Let a = 21 and b = 29

So to find 21, O(log n) time required to find 29, O (long n) time required and in the range there are K elements. So it can be found in K time by inorder travers.

So total time = O(2 logn +K) = O(logn + K)

46. For $n > 2$, let $a \in \{0,1\}^n$ be a non-zero vector. Suppose that x is chosen uniformly at random from $\{0,1\}^n$. Then, the probability that $\sum_{i=1}^{n} a_i x_i$ is an odd number is _____.

Key: **(0.5)**

Sol: $a = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$ $x = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$

$a_i = 0$ or 1

$x_i = 0$ or 1

$\sum_{i=1}^{n} a_i x_i$ values lies between 0 to n.

So total cases are 2^n

$a_i x_i$	0	1	2	....	n
f_{av}	n_{C_0}	n_{C_1}	n_{C_2}	....	n_{C_n}

Then the probability that $\sum_{i=1}^{n} a_i x_i$ is an odd number is

$$= \frac{n_{C_1} + n_{C_3} + \ldots}{2^n} = \frac{2^{n-1}}{2^n} = \frac{1}{2} = 0.5$$

47. Consider the following C functions.

```
int tob (int b, int* arr) {
    int i;
    for (i = 0; b > 0; i++) {
    if (b%2) arr[i] = 1;
    else arr[i] = 0;
    b = b/2;

    }
    return (i);
}
```

```
int pp(int a, int b) {
int arr[20];
int i, tot = 1, ex, len;
ex = a;
len = tob (b, arr);
for (i = 0; i<len; i++) {
     if (arr [i] == 1)
         tot = tot * ex;
     ex = ex * ex;
}
Return (tot);
}
```

The value returned by $pp(3,4)$ is _____.

Key: (81)

Sol: $PP(3,4)$

$tot = 1, ex = 3;$

$len = tob(4, arr);$

$for(i = 0; 4 > 0, b > 0 : i{+}{+})$

1	1	0
$arr[0]$	$arr[1]$	$arr[2]$

Final value of i=3;

```
len = 3
for(i = 0; i < 3; i++)
{
if (arr[i] == 1)
tot = tot * εx;
ε* = εx * εx;
}
return (tot);
}
```

Final return value is 81.

48. Each of a set of n processes executes the following code using two semaphores a and b initialized to 1 and 0, respectively. Assume that count is a shared variable initialized to 0 and not used in CODE SECTION P.

CODE SECTION P

```
Wait (a); count = count + 1;
if (count ==n) signal (b);
signal (a); wait (b); signal (b);
```

CODE SECTION Q

What does the code achieve?

(A) It ensures that at most n–1 processes are in CODE SECTION P at any time.

(B) It ensures that at most two processes are in CODE SECTION Q at any time.

(C) It ensures that no process executes CODE SECTION Q before every process has finished CODE SECTION P.

(D) It ensures that all processes execute CODE SECTION P mutually exclusively.

Key: (C)

Sol: Initial values,

Count = 0; a = 1; b = 0; Assume that, n = 4 $[P_1\ P_2\ P_3\ P_4]$

P_1	P_2

Count; a = 1; b = 0; n = 4
Code section P
Wait (a); //a = 0
Count = count +1; //count = 1
	Count = 1; a = 1; b= 0; n = 4
	Code Section P
	Wait (a); //a = 0
	Count = count + 1; //count = 0

If (count = n) condition false
{signal (b);} doesn't execute
Signal (a); //a = 1
Wait (b); (P_1) **struck here**
Signal (b);
Code section Q
	If (count = = n) condition false
	{signal (b); doesn't execute
	Signal (a); //a= 1
	Wait (b); (P_2) **struck here**
	Signal (b);
	Code section Q

P_4	P_3

Count 3; a = 1; b = 0; n = 4
Code section P
Wait (a); //a = 0
Count = count +1; //count = 4
If (count = n) condition true
{signal (b);}// b = 1
Wait (b); //b = 0
Signal (b); //b = 1
Code section Q
P_4 is completed
	Count =2 ; a = 1; b = 0; n = 4
	Code section P
	Wait (a); //a = 0
	Count = count +1; //count = 3
	If (count = n) //condition is false
	{signal (b);} doesn't execute
	Signal (a); //a = 1
	Wait (b); (P_3) **struck here**
	Signal (b);
	Code section Q

First P_4 can complete both code section P and Q. Later remaining 3 processes can complete code section P and Q.

$\therefore$ It is clear that no process executes code section Q before every process has finished code section P .

Hence option C is correct.

49. Consider the array representation of binary min-heap containing 1023 elements.

The minimum number of comparisons required to find the maximum in the heap is _____.

Key: (511)

Sol: Number of elements in Binary min heap = 1023, so maximum element should be at leaf level.

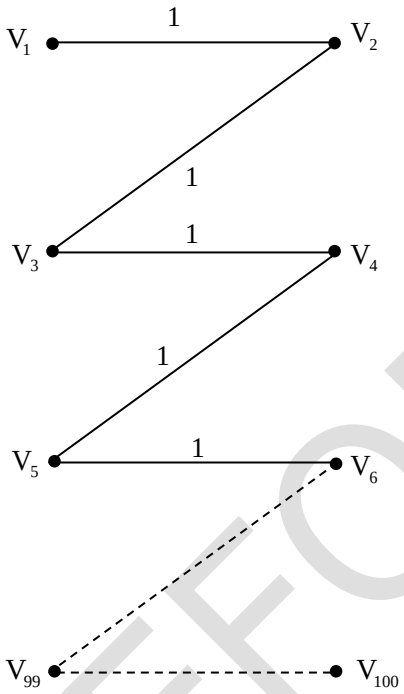
So total number of leaf node for n node binary tree $= \left\lceil \frac{n}{2} \right\rceil = 512$

So, total comparison = 511 (Using bubble sort).

50. Consider a graph G = (V, E), where $V = \{v_1, v_2, ..., v_{100}\}$, $E = \{(v_i, v_j) | 1 \le i < j \le 100\}$, and weight of the edge (v_i, v_j) is $|i - j|$. The weight of minimum spanning tree of G is _____.

Key: (99)

Sol: The spanning contain 99 edge and 100 vertices and weight of each edge is on



Total vertices = 100

Edge = 99 and weight of Each edge = 1.

So, total weight = 99

51. Consider the following five disk access requests of the form (request id, cylinder number) that are present in the disk scheduler queue at a given time.

(P, 155), (Q, 85), (R, 110), (S, 30), (T, 115)

Assume the head is positioned at cylindrical 100. The scheduler follows shortestSeek Time First scheduling to service the requests.

Which one of the following statements is FALSE?

(A) Q is serviced after S, but before T.

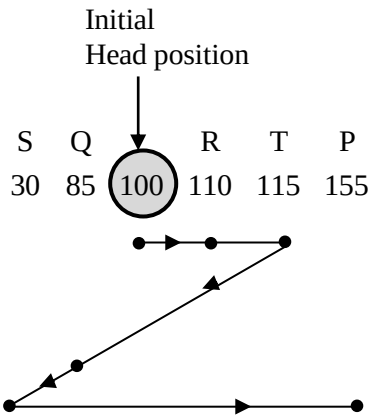
(B) The head reverses its direction of movement between servicing of Q and P.

(C) R is serviced before P.

(D) T is serviced before P.

Key: (A)

Sol:



According to above servicing order of cylinders using SSTF, option A is false, which is the correct answer.

52. Consider a non-pipelined processor operating at 2.5 GHz. It takes 5 clock cycles to complete an instruction. You are going to make a 5-stage pipeline out of this processor. Overheads associated with pipelining force you to operate the pipelined processor at 2 GHz. In a given program, assume that 30% are memory instructions, 60% are ALU instructions and the rest are branch instructions. 5% of the memory instructions cause stalls of 50 clock cycles each due to cache misses and 50% of the branch instructions cause stalls of 2 cycles each. Assume that there are no stalls associated with the execution of ALU instructions. For this program, the speedup achieved by the pipelined processor over the non-pipelined processor (round off to 2 decimal places) is _____.

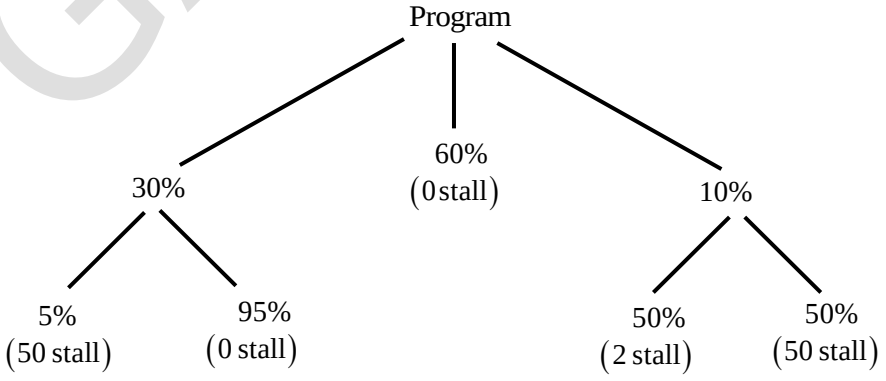
Key: (2.16)

Sol: For non-pipeline $t_n = 5CC = 5 \times \frac{1}{2.5} n\sec$

$t_n = 2n\sec$

For pipeline:-

Average clock cycle/Inst^n is



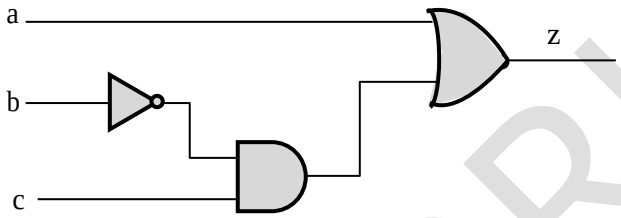
$$\text{Average CC/Inst}^{n} = 0.3*0.05*(50+1)+0.3\times0.95\times1+0.6*1+0.1*0.5*(1+2)+0.1*0.5*1=1.85\ \text{CC}$$

$$\text{So, time} = 1.85*\frac{1}{2}\text{n sec}$$

$$t_p = 0.925\ \text{n sec}$$

$$\text{Speed up } \frac{t_n}{t_p} = \frac{2}{0.925} = 2.16$$

53. Consider the Boolean function z(a, b, c)



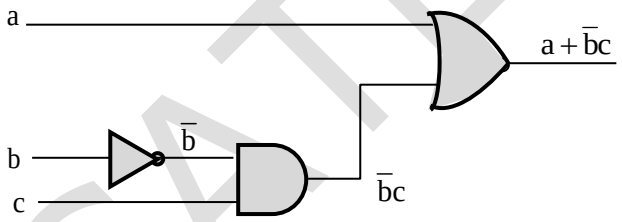
Which one of the following minterm lists represents the circuit given above?

(A) $z=\Sigma(1,4,5,6,7)$ (B) $z=\Sigma(2,3,5)$

(C) $z=\Sigma(2,4,5,6,7)$ (D) $z=\Sigma(0,1,3,7)$

Key: (A)

Sol:



$f = a+\bar{b}c$

$\Sigma(1,4,5,7,6)$

a \ bc	$\bar{b}\bar{c}$	$\bar{b}c$	bc	$b\bar{c}$
$\bar{a}$	0	1 1	3	2
a	1 4	1 5	1 7	1 6

54. Consider the following set of processes, assumed to have arrived at time 0. Consider the CPU scheduling algorithms Shortest Job First (SJF) and Round Robin (RR). For RR. Assume that the processes are scheduled in the order P_1, P_2, P_3, P_4.

Processes	P_1	P_2	P_3	P_4
Burst time (in ms)	8	7	2	4

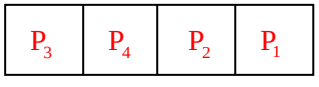
If the time quantum for RR is 4 ms, then the absolute value of the difference between the average turnaround times (in ms) of SJF and RR (round off to 2 decimal places) is _____.

Key: (5.25)

Sol: Non preemptive SJF

PID	AT	BT	CT	TAT
P_1	0	8	21	21
P_2	0	7	13	13
P_3	0	2	2	2
P_4	0	4	6	6

Gantt chart:

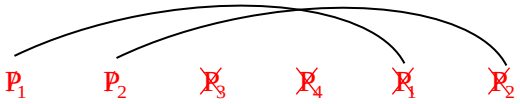


P_1-8 P_1-8 P_1-8 P_1-8
P_2-7 P_2-7 P_2-7
P_3-2 P_4-4
P_4-4

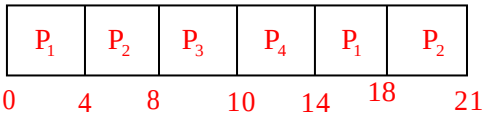
$\therefore$ Average TAT $= \frac{21+13+2+6}{4} = \frac{42}{4} = 10.5$

Round Robin with T. Q = 4

PID	AT	BT	CT	TAT
P_1	0	8	18	18
P_2	0	7	21	21
P_3	0	2	10	10
P_4	0	4	14	14

Ready queue: 

Gantt chart:



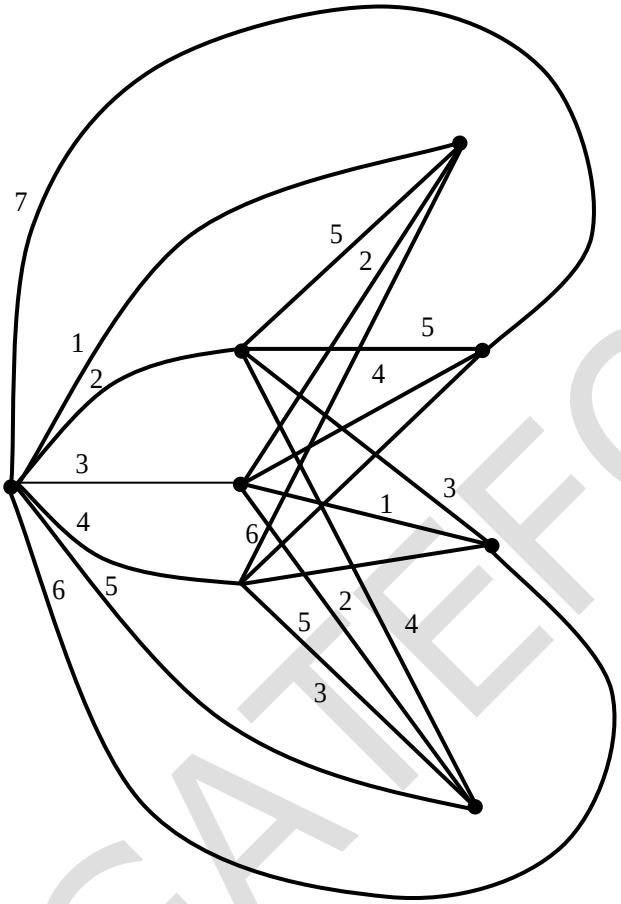
$\therefore$ Average TAT $= \dfrac{18+21+10+14}{4} = \dfrac{63}{4} = 15.75$

$\therefore$ Difference $= 15.75 - 10.50 = 5.25$

55. Graph G is obtained by adding vertex s to $K_{3.4}$ and making s adjacent to every vertex of $K_{3,4}$. The minimum number of colours required to edge-colour G is _____.

Key: (7)

Sol:



$\therefore$ 7 – colours required.