GENERAL APTITUDE

Q.No. 1-5 Carry One Mark Each

1. The _____ is too high for it to be considered _____.

(A) fair / fare (B) faer / fair (C) fare / fare (D) fare / fair

2. A function y(x) is defined in the interval [0, 1] on the x-axis as

$$y(x)=\begin{cases}2 & \text{if} \quad 0\le x<\frac{1}{3}\\ 3 & \text{if} \quad \frac{1}{3}\le x<\frac{3}{4}\\ 1 & \text{if} \quad \frac{3}{4}\le x\le 1\end{cases}$$

Which one of the following is the area under the curve for the interval [0, 1] on the x-axis?

(A) $\frac{5}{6}$ (B) $\frac{6}{5}$ (C) $\frac{13}{6}$ (D) $\frac{6}{13}$

3. Let r be a root of equation $x^2+2x+6=0$

Then the value of expression $(r+2)(r+3)(r+4)(r+5)$ is

(A) 51 (B) –51 (C) 126 (D) –126

4. Given below are four statements.

Statement 1: All students are inquisitive.

Statement 2: Some students are inquisitive.

Statement 3: No student is inquisitive.

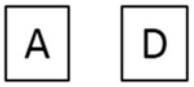
Statement 4: Some students are not inquisitive.

From the given four statements, find the two statements that **CANNOT BE TRUE** simultaneously, assuming that there is at least one student in the class.

(A) Statement 1 and Statement 3 (B) Statement 1 and Statement 2

(C) Statement 2 and Statement 4 (D) Statement 3 and Statement 4

5. A palindrome is a word that reads the same forwards and backwards. In a game of words, a player has the following two plates painted with letters.



From the additional plates given in the options, which one of the combinations of additional plates would allow the player to construct a five-letter palindrome. The player should use all the five plates exactly once. The plates can be rotated in their plane.

(A) 

(B) 

(C) 

(D) 

Q.No. 6-10 Carry Two Marks Each

6. Some people believe that "what gets measured, improves". Some others believe that "what gets measured, gets gamed". One possible reason for the difference in the beliefs is the work culture in organizations. In organizations with good work culture, metrics help improve outcomes. However, the same metrics are counterproductive in organizations with poor work culture.

Which one of the following is the CORRECT logical inference based on the information in the above passage?

(A) Metrics are useful in organizations with poor work culture

(B) Metrics are useful in organizations with good work culture

(C) Metrics are always counterproductive in organizations with good work culture

(D) Metrics are never useful in organizations with good work culture

7. In a recently conducted national entrance test, boys constituted 65% of those who appeared for the test. Girls constituted the remaining candidates and they accounted for 60% of the qualified candidates. Which one of the following is the correct logical inference based on the information provided in the above passage?

(A) Equal number of boys and girls qualified

(B) Equal number of boys and girls appeared for the test

(C) The number of boys who appeared for the test is less than the number of girls who appeared

(D) The number of boys who qualified the test is less than the number of girls who qualified

8. A box contains five balls of same size and shape. Three of them are green coloured balls and two of them are orange coloured balls. Balls are drawn from the box one at a time. If a green ball is drawn, it is not replaced. If an orange ball is drawn, it is replaced with another orange ball.

First ball is drawn. What is the probability of getting an orange ball in the next draw?

(A) $\frac{1}{2}$ (B) $\frac{8}{25}$ (C) $\frac{19}{50}$ (D) $\frac{23}{50}$

9. The corners and mid-points of the sides of a triangle are named using the distinct letters P, Q, R, S, T and U, but not necessarily in the same order. Consider the following statements:

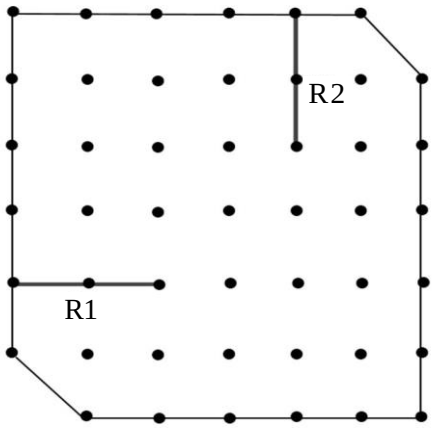
- The line joining P and R is parallel to the line joining Q and S.
- P is placed on the side opposite to the corner T.
- S and U cannot be placed on the same side.

Which one of the following statements is correct based on the above information?

(A) P cannot be placed at a corner (B) S cannot be placed at a corner

(C) U cannot be placed at a mid-point (D) R cannot be placed at a corner

10. A plot of land must be divided between four families. They want their individual plots to be similar in shape, not necessarily equal in area. The land has equally spaced poles, marked as dots in the below figure. Two ropes, R1 and R2, are already present and cannot be moved. What is the least number of additional straight ropes needed to create the desired plots? A single rope can pass through three poles that are aligned in a straight line.



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

COMPUTER SCIENCE ENGINEERING

Q. No. 11- 35 Carry One Mark Each

11. Which one of the following statements is TRUE for all positive functions f(n)?

(A) $f\left(n^2\right)=\theta\left(f\left(n\right)^2\right)$ when f(n) is a polynomial

(B) $f\left(n^2\right)=o\left(f\left(n\right)^2\right)$

(C) $f\left(n^2\right)=O\left(f\left(n\right)^2\right)$, when f(n) is an exponential function

(D) $f\left(n^2\right)=\Omega\left(f\left(n\right)^2\right)$

Key: (A)

Sol: Take f(n) = log (n)

So, $f\left(n^2\right)=\log\left(n^2\right)=2\log n$

Hence, option D is false

For $f\left(n\right)=2^n$, Option C is false

For f(n) = n, Option B is false.

Hence, the answer is option A.

Method-II:

Option A:

$f\left(n^2\right)=\theta\left(f\left(n\right)\right)^2$ where f is polynomial

Let $f\left(n\right)=an^k$ then

$f\left(n^2\right)=an^{2k}$ and $\left(f\left(n\right)\right)^2=a^2n^{2k}$

Hence $f\left(n^2\right)=\theta\left(f\left(n\right)\right)^2$

Option A is correct

Option (B): $f\left(n^2\right)=o\left(f\left(n\right)\right)^2$

Here $f\left(n\right)$ could be any function

$f\left(n^2\right)<\left(f\left(n\right)\right)^2$ is not free when f(n) is polynomial.

Option (C): $f\left(n^2\right)=O\left(f\left(n\right)\right)^2$

When f(n) is exponential

$f\left(n^2\right) \le \left(f\left(n\right)\right)^2$

$f\left(n\right) = e^n \Rightarrow f\left(n^2\right) = e^{n^2}$ and $\left(f\left(n\right)\right)^2 = e^{2n}$

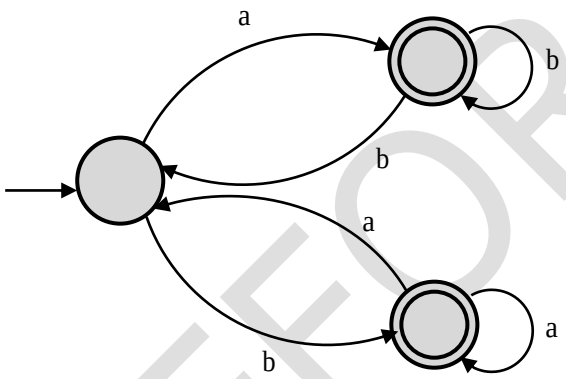
$\Rightarrow e^{n^2} \le e^{2n}$ is false

Option (D): $f\left(n^2\right) = \Omega f\left(n^2\right)$

$f\left(n^2\right) \ge \left(f\left(n\right)\right)^2$

If $f\left(n\right) = \log n$ then it is false

12. Which one of the following regular expressions correctly represents the language of the finite automaton given below?



(A) $ab*bab*+ba*aba*$

(B) $(ab*b)ab*+(ba*a)*ba*$

(C) $(ab*b+ba*a)(a*+b*)$

(D) $(ba*a+ab*b)(ab*+ba*)$

Key: (D)

Sol: Counter example for option A:

The Strings "a" is accepted by the given NFA BUT this string is Not generated by theregular expression in Option A. So Option A is wrong.

Option B:The String abbbaa is accepted by the given NFA BUT this string is Not generated by theregular expression in Option B. So Option B is wrong.

Option C:The Empty String is NOT accepted by the given NFA BUT this string is generated by theregular expression in Option C. So Option C is wrong.

Correct answer is D.

13. Which one of the following statements is TRUE?

(A) The LALR (1) parser for a grammar G cannot have reduce-reduce conflict if the LR(1) parser for G does not have reduce-reduce conflict.

(B) Symbol table is accessed only during the lexical analysis phase.

(C) Data flow analysis is necessary for run-time memory management

(D) LR(1) parsing is sufficient for deterministic context-free languages.

Key: (D)

Sol: Option A. LALR can have RR conflict even when lr(1) does not have RR conflict

Option B. Symbol table is accessed in all phases

Option C. DataFlow analysis is optional

Option D. Every deterministic context-free language is LR(1)

14. In a relational data model, which one of the following statements is TRUE?

(A) A relation with only two attributes is always in BCNF.

(B) If all attributes of a relation are prime attributes, then the relation is in BCNF.

(C) Every relation has at least one non-prime attribute.

(D) BCNF decompositions preserve functional dependencies.

Key: (A)

Sol: A relation with only two attributes is always in BCNF.

For Example, there is a relation R = {A,B} with two attributes.

The only possible (non-trivial) FD's are $\{A\} \rightarrow \{B\}$ and $\{B\} \rightarrow \{A\}$.

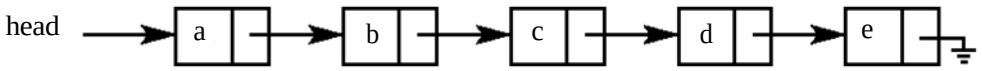
So, there are four possible cases:

1. No FD's holds in R. {C.K = AB}, Since it is an all key relation it's always in BCNF.
2. Only $A \rightarrow B$ holds. In this case {C.K = A} and relation satisfies BCNF.
3. Only $B \rightarrow A$ holds. In this case {C.K = B} and relation satisfies BCNF.
4. Both $A \rightarrow B$ and $B \rightarrow A$ holds. In this case there are two keys {CK = A and B} andrelation satisfies BCNF.

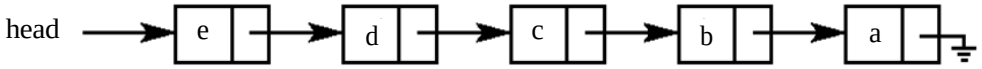
Hence, every Binary Relation (A relation with two attributes) is always in BCNF!

15. Consider the problem of reversing a singly linked list. To take an example, given the linked list below, the reversed linked list should look like

Which one of the following statements is TRUE about the time complexity of algorithms that solve the above problem in O(1) space?



the reversed linked list should look like



(A) The best algorithm for the problem takes $\theta(n)$ time in worst case.

(B) The best algorithm for the problem takes $\theta(n \log n)$ time in the worst case

(C) The best algorithm for the problem takes $\theta(n^2)$ time in the worst case

(D) It is not possible to reverse a singly linked list in O (1) space.

Key: (A)

Sol: Can be done in theta(n) using 3 pointers. See following code

```
struct node * reverse( struct node * head )
{
    struct node * prevP = NULL;
    struct node * nextP = head→next;
    while(head != NULL) {
       head→next = prevP;
       prevP = head;
       head = nextP;
       nextP = head→next;
    }
    return prevP;
}
```

16. Suppose we are given n keys, m has table slots, and two simple uniform hash functions $h_1$and h_2. Further suppose our hashing scheme uses h_1 for the odd keys and h_2 for the even keys. What is the expected number of keys in a slot?

(A) $\frac{m}{n}$ (B) $\frac{n}{m}$ (C) $\frac{2n}{m}$ (D) $\frac{n}{2m}$

Key: (B)

Sol: Both h1, h2 are simple uniform hash functions. So, using any of them, for any key k, each slot is equally likely. i.e. whatever key k we take, on this key. Whatever hash function (h1 or h2) we apply, each bucket/slot is equally likely to be occupied.

So, for each slot, the probability that it will be occupied for any key is 1/m

Hence the expected number of keys in a slit is n/m.

17. Which one of the following facilitates transfer of bulk data from hard disk to main memory with the highest through put?

(A) DMA based I/O transfer
(B) Interrupt driven I/O transfer
(C) Polling based I/O transfer
(D) Programmed I/O transfer

Key: (A)

Sol: DMA is used for bulk data transfer from hard disk to main memory

18. Let R1 and R2 be two 4-bit registers that store numbers in 2's complement form. For the operation R1+ R2, which one of the following values of R1 and R2 gives an arithmetic overflow?

(A) R1 = 1011 and R2 = 1110
(B) R1 = 1100 and R2 = 1010
(C) R1 = 0011 and R2 = 0100
(D) R1 = 1001 and R2 = 1111

Key: (B)

Sol: 2's complement range for 4 bits = [-8. 7]

Option A

R1 = 1011 = –5 and R2 = 1110 = –2. R1+R2 = –7 No overflow

Option B

R1 = 1100 = –4 and R2 = 1010 = -6. R1+R2 = –10 Overflow

Option C

R1 = 0011 = 3 and R2 = 0100 = 4. R1+R2 = 7 No overflow

Option D

R1 = 1001 = –7 and R2 = 1111 = -1. R1+R2 = –8 No overflow

19. Consider the following threads, T_1, T_2, and T_3 executing on a single processor, synchronized using three binary semaphore variables, S_1, S_2, and S_3, operated upon using standard wait() and signal(). The threads can be context switched in any order and at any time.

T_1	T_2	T_3

while(true){
wait(S_3);
print("C");
signal(S_2); }
	while(true){
	wait(S_1);
	print("B");
	signal(S_3); }
		while(true){
		wait(S_2);
		print("A");
		signal(S_1); }

Which initialization of the semaphores would print the sequence BCABCABCA….?

(A) $S_1 = 1; S_2 = 1 ; S_3 = 1$
(B) $S_1 = 1; S_2 = 1 ; S_3 = 0$
(C) $S_1 = 1; S_2 = 0 ; S_3 = 0$
(D) $S_1 = 0; S_2 = 1 ; S_3 = 1$

Key: **(C)**

Sol: We need to print B first hence T1 and T3 should wait.

First T2 should be able to print. Hence, binary semaphore S1 must be 1 initially.

Clearly, first T1 Or T3 should not be able to print, So, S3=0,S2=0 initially.

20. Consider the following two statements with respect to the matrices A_{mxn}, B_{nxm}, C_{nxn} and D_{mxm}

Statement 1 : tr(AB) = tr(BA)

Statement 2 : tr(CD) = tr(DC)

where tr( ) represents the trace of a matrix. Which one of the following holds?

(A) Statement 1 is correct and Statement 2 is wrong.

(B) Statement 1 is wrong and Statement 2 is correct.

(C) Both Statement 1 and Statement 2 are correct.

(D) Both Statement 1 and Statement 2 are wrong.

Key: (C)

Sol: Trace of a matrix is the same as the sum of eigenvalues.

AB and BA have the same nonzero eigenvalues, hence the trace is also same for both.

21. What is printed by the following ANSI program?

```
#include <studio.h>
int main(int argc, char *argv[])
{
int x = 1, z[2] = {10, 11};
int *p = NULL;
p = &x;
*p = 10;
p = &z[1];
*(&z[0] + 1) + = 3;
printf("%d, %d, %d\n", x, z[0], z[1]);
return 0;
}
```

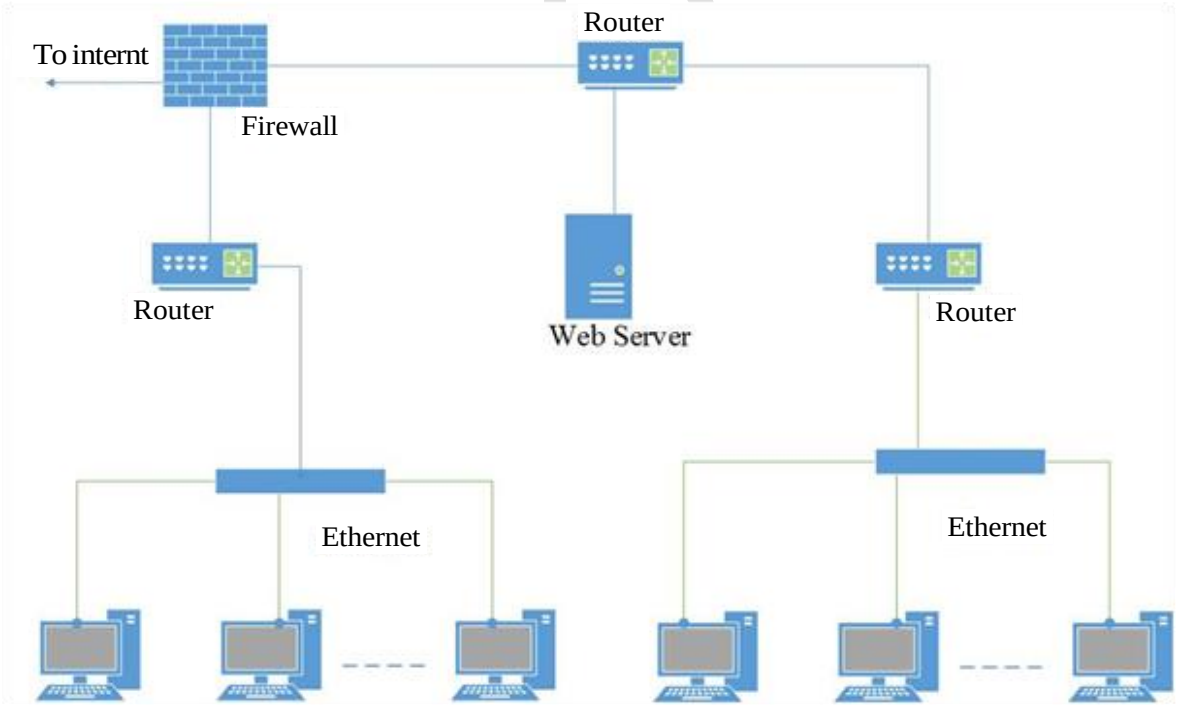
(A) 1, 10, 11 (B) 1, 10, 14 (C) 10, 14, 11 (D) 10, 10, 14

Key: **(D)**

Sol: Below code is commented with explanation

```
int main(int argc, char *argv[])
{
    int x = 1, z[2] = {10, 11};
    int * p = NULL;
    p = & x; // p is pointing to x
    *p = 10; // value of x is updated to 10
    p = &z[1]; //p is pointing to z[1]
    *(& z [0] + 1) += 3; // &z[0] + 1 means address of z[1], this updates z[1] to 14
    printf("%d, %d, %d\n", x, z[0], z[1]); //10 10 14 will get printed
    return 0;
}
```

22. Consider an enterprise network with two Ethernet segments, a web server and a firewall, connected via three routers as shown below.



What is the number of subnets inside the enterprise network?

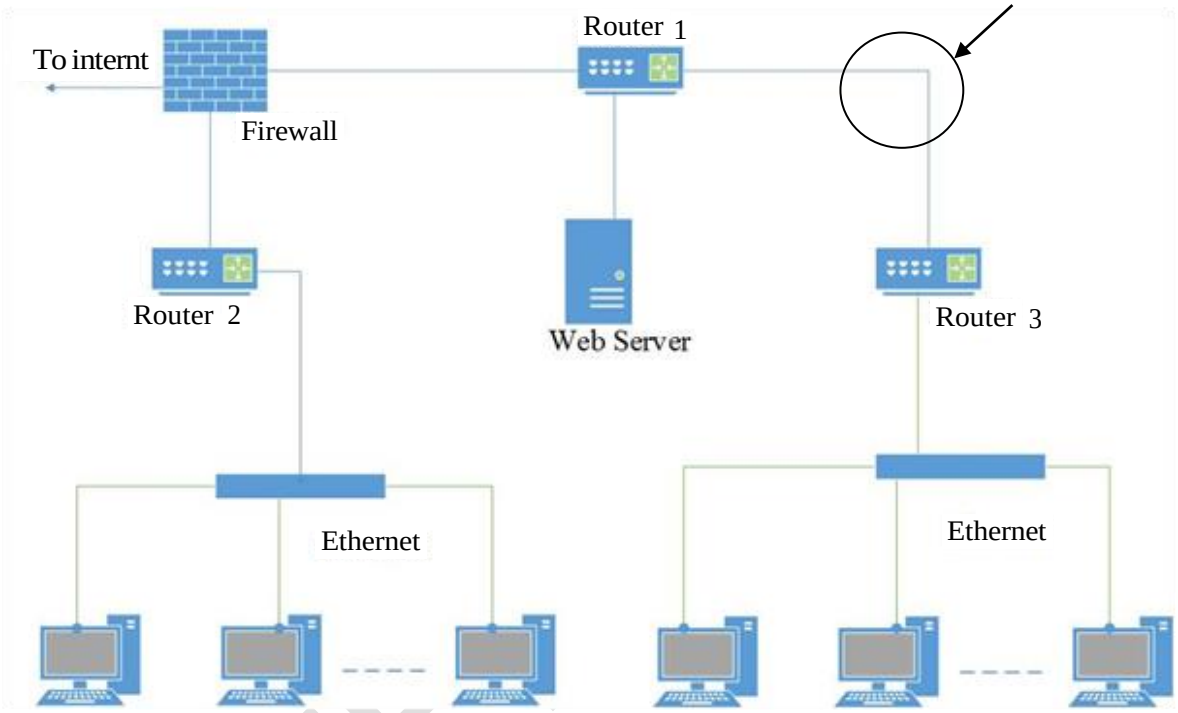
(A) 3 (B) 12 (C) 6 (D) 8

Key: (6)

Sol: Each interface connected to the router has its own ip address. The same ip address isused by the router in the routing table. Each entry of the routing table represents onenetwork.

Hence number of interfaces to router = number of subnets = 2 + 3 + 2 = 7

Since one of the interfaces is common in router 1 and 3 therefore 7-1 = 6 is answer.



23. Which of the following statements is / are TRUE ?

(A) Every subset of a recursively enumerable language is recursive.

(B) If a language L and its complement $\bar{L}$ are both recursively enumerable, then L must be recursive.

(C) Complement of a content-free language must be recursive

(D) If L_1 and L_2 are regular then $L_1 \cap L_2$ must be deterministic context – free

Key: (B, C, D)

Sol: Option A: Every subset of a recursively enumerable language is recursive.

Consider Σ*- which is a regular language. Every regular language is recursivelyenumerable therefore Σ*is also recursively enumerable. Now consider any nonrecursive language, it has to be subset of Σ*since it is universal set.Therefore there are non recursive languages which are subset of recursive enumerablelanguage. Hence this option is false

Option B: A recursive language is one that is accepted by a TM that halts on all inputs.

The complement of a recursive language is recursive.

Option C: Recursive languages are closed under complementation. A CFL is alsorecursive language.

Option D: If L1 and L2 are regular then there intersection is also regular. Since everyregular is DCFL hence L1 ∩ L2 is DCFL.

24. Let WB and WT be two set associative cache organizations that use LRU algorithm for cache block replacement. WB is a write back cache and WT is a write through cache. Which of the following statements is/are FALSE?

(A) Each cache block in WB and WT has a dirty bit.

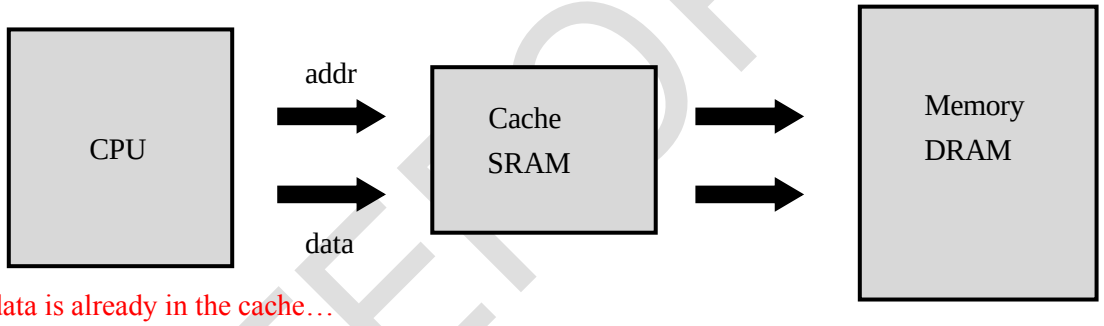
(B) Every write hit in WB leads to a data transfer from cache to main memory.

(C) Eviction of a block from WT will not lead to data transfer from cache to main memory.

(D) A read miss in WB will never lead to eviction of a dirty block from WB.

Key: (A, B, D)

Sol: How to write data



If data is already in the cache…

No-write

- writes invalidate the cache and go directly to memory

Write-Through

- writes go to main memory and cache

Write-Back

- CPU writes only to cache
- cache writes to main memory later (when block is evicted)

About Stores

Where should you write the result of a store

- If that memory location in the cache?

  – Send it to the cache

  – Should we also send it to memory right away?

  (Write-through policy)

– Wait until we kick the block out (write-back policy)

- If it is not in the cache?

– Allocate the line (put it in the cache)?

(write allocate policy)

– Write it directly to memory without allocation?

(no write allocate policy)

Eviction of a block from WT will not lead to data transfer from cache to main memory.

25. Consider the following three relations in a relational database.

Employee (eId, Name), Brand (bId,bName), Own(eId, bId)

Which of the following relational algebra expressions return the set of eIds who own all the brands?

(A) $\Pi_{eId}\Pi_{eId,bId}(Own)/\Pi_{bId}(Brand))$

(B) $\Pi_{eId}(Own)-\Pi_{eId}\left((\Pi_{eId}(Own)\times\Pi_{bId}(Brand))-\Pi_{eId,bId}(Own)\right)$

(C) $\Pi_{eId}\left(\Pi_{eId,bId}(Own)/\Pi_{bId}(Own)\right)$

(D) $\Pi_{eId}\left(\Pi_{eId}((Own)\times\Pi_{bId}(Own))/\Pi_{bId}(Brand)\right)$

Key: (A, B)

Sol: Set of eIds who own all the brands can be given by division operation henceA is correct. Option B is also simplified form of division operator.

26. Which of the following statements is/are TRUE with respect to deadlocks?

(A) Circular wait is a necessary condition for the formation of deadlock.

(B) In a system where each resource has more than one instance, a cycle in its wait-for graph indicates the presence of a deadlock.

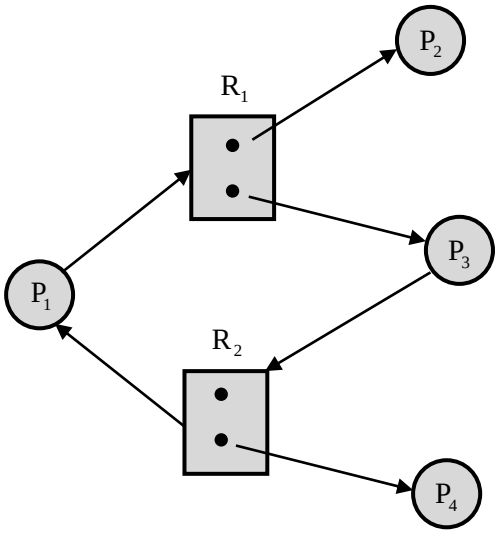
(C) If the current allocation of resources to processes leads the system to unsafe state, then deadlock will necessarily occur.

(D) In the resource-allocation graph of a system, if every edge is an assignment edge, then the system is not in deadlock state.

Key: (A, D)

Sol: Option A: True since circular wait is one of the necessary conditions out of fourconditions of deadlock.

Option B:False. Cycle in multi instance does not necessarily mean deadlock. Considerbelow example as counter case



Option C: Unsafe state means deadlock may occur. There is no guarantee, it may ormay not occur.

Option D: In that case there will not be any circular wait hence no deadlock.

27. Which of the following statements is/are TRUE for a group G?

(A) If for all $x, y \in G, (xy)^2 = x^2y^2$, then G is commutative.

(B) If for all $\in G, x^2 = 1$, then G is commutative, Here, 1 is the identity element of G.

(C) If the order G is 2, then G is commutative.

(D) If G is commutative, then a subgroup of G need not be commutative.

Key: (A, B, C)

Sol: Option A:

lif $(xy)^2 = x^2y^2$ then group is commutative. Ture

Proof.

LHS: $(xy)^2 = xyxy$ and RHS: $x^2y^2 = xxyy$

Now, $(xy)^2 = x^2y^2$

$\Rightarrow xyxy = xxyy$

$\Rightarrow yx = xy$ (pre cancellation of x and post cancellation of y)

$\Rightarrow$ group is commutative

Option B:

Consider element in group $g.h$

Since for any element in group it is given that $x^2 = 1$ hence $(g.h)^2 = 1$

Which means $g.\ h$ is inverse of itself.

Next we prove that g. h has h.g as inverse, since inverse is unique hence we will say that g. h = h. g which makes the group as commutative.

g. h.h.g = g. 1. g = g. g = 1. This shows $g.\ h$ has $h.\ g$ as inverse.

Option C

Every group of prime order is cyclic and hence abelian. 2 is a prime number.

Option D:

It is false since every subgroup of an abelian group has to be abelian.

Proof:

If subgroup contains element a, b then ab = ba(because parent group is abelian) and subgroup is also group which means it is closed.

Hence ab (or ba) is also part of subgroup.

28. Suppose a binary search tree with 1000 distinct elements is also a complete binary tree. The tree is stored using the array representation of binary heap trees. Assuming that the array indices start with 0, the 3rd largest element of the tree is stored at index_____

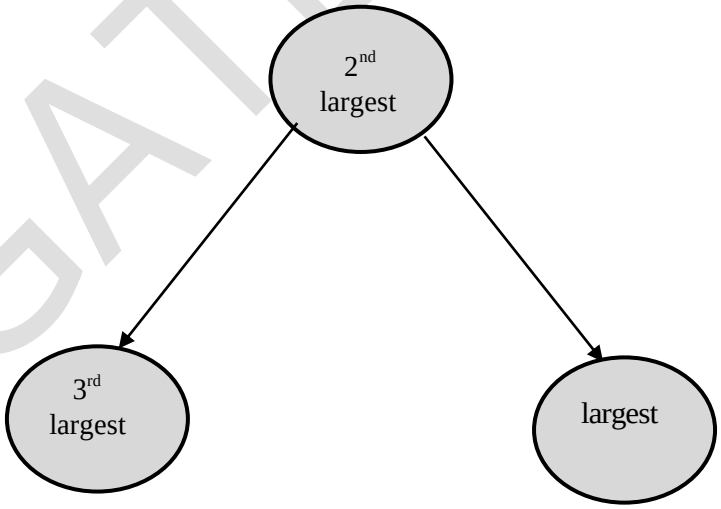
Key: (509)

Sol: The last level will not be completely filled since we only have 1000 nodes.

Largest node will be on rightmost side

2nd largest will be parent on largest

3rd largest will be inorder predecessor of 2nd largest. In this case, since last level is notfilled completely, inorder predecessor will be left child in this case.



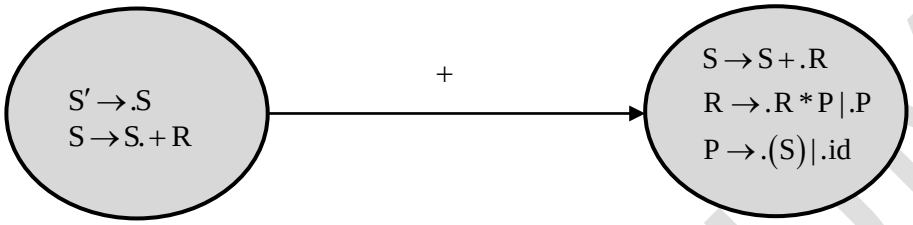
29. Consider the augmented grammar with $\{+,*,(,),\text{id}\}$ as the set of terminals.

(A) $S' \to S$ (B) $S \to S+R \mid R$ (C) $R \to R*P \mid P$ (D) $P \to (S) \mid \text{id}$

If I_0 is the set of two LR(0) items $\{[S' \to S.], [S \to S.+R]\}$, then goto (closure($I_0$) +) contains exactly _____ items.

Key: (5)

Sol:



30. Consider a simple undirected graph of 10 vertices. If the graph is disconnected, then the maximum number of edges it can have is _____.

Key: (36)

Sol: For maximum number of edges, we want more vertices to come together. This ispossible when we have a component with 9 vertices and other with 1 vertex.

Number of edges $= 9C_2 = \frac{9\times 8}{2} = 36$

31. Consider a relation R(A,B,C,D,E) with the following three functional dependencies.

$AB \to C;\ BC \to D;\ C \to E;$

The number of superkeys in the relation R is _____.

Key: (8)

Sol: It is clear that every key must contain A, B.

Now there are 3 attributes remaining –C, D or E.

Either we take one of these attributes or we do not. Hence 2 × 2 × 2 = 8 is the answer.

32. The number of arrangements of six identical balls in three identical bins is

Key: (7)

Sol: There is no formula for identical balls and identical bins hence we need to countmanually.

Case 1: If only one bin is used (6,0,0)

Case 2: If two bins are used : (5,1,0), (4,2,0), (3,3,0)

Case 3: If three bins are used : (4,1,1), (3,2,1), (2,2,2)

Total 7 ways.

33. A cache memory that has a hit rate of 0.8 has an access latency 10ns and miss penalty 100ns. An optimization is done on the cache to reduce the miss rate. However, the optimization results in an increase of cache access latency to 15 ns, whereas the miss penalty is not affected. The minimum hit rate (rounded off to two decimal places) needed after the optimization such that it should not increase the average memory access time is _____

Key: (0.85)

Sol: For a given cache, Average memory access time can be computed as:

AMAT = Hit Time + Miss rate * Miss Penalty

Initially,

Hit rate of cache = 0.8

$\therefore$ Miss rate = 0.2

Access Latency = Hit Time = 10 ns

Miss Penalty = 100 ns

$\therefore \quad \text{AMAT}_{\text{unoptimized}} = 10 + 0.2(100) = 30 \text{ ns}$

For the optimized cache,

Access Latency = Hit rate = 15 ns

$\therefore \quad \text{AMAT}_{\text{optimized}} = 15 + x(100)$

Now $\text{AMAT}_{\text{unoptimized}} \geq \text{AMAT}_{\text{optimized}}$

$30 \geq 15 + 100x \Rightarrow 15 \geq 100x \Rightarrow 0.15 \geq x \Rightarrow 0.85 \leq 1 - x$

$\therefore$ The required hit rate $= (1 - x) = 0.85$

34. The value of the following limit is _____

$$\lim_{x \to 0+} \frac{\sqrt{x}}{1 - e^{2\sqrt{x}}}$$

Key: (–0.5)

Sol: We can solve using the L hospital rule.

$$\lim_{x \to 0+} \frac{\sqrt{x}}{1 - e^{2\sqrt{x}}} \left(\frac{0}{0} \text{form} \right)$$

Using L'Hospital's rule

$$\lim_{x \to 0+} \frac{\frac{1}{2\sqrt{x}}}{0 - e^{2\sqrt{x}} \cdot \frac{2}{2\sqrt{x}}} = \lim_{x \to 0+} -\frac{1}{2.e^{2\sqrt{x}}} = -\frac{1}{2} = -0.5$$

35. Consider the resolution of the domain name `www.gate.org.in` by a DNS resolver. Assume that no resource records are cached anywhere across the DNS servers and that iterative query mechanism is used in the resolution. The number of DNS query-response pairs involved in completely resolving the domain name is_____.

Key: (4)

Sol: DNS query first goes to local DNS server by default. And then there are 3 more DNSservers – Root, TLD and authoritative DNS server (in the same order).

36. Which one of the following is the closed form for the generating function of the sequence $\{a_n\}_{n\geq 0}$ defined below?

$$a_n = \begin{cases} n+1, & n \text{ is odd} \\ 1, & \text{otherwise} \end{cases}$$

(A) $\frac{x(1+x^2)}{(1-x^2)^2}+\frac{1}{1-x}$ (B) $\frac{x(3-x^2)}{(1-x^2)^2}+\frac{1}{1-x}$ (C) $\frac{2x}{(1-x^2)^2}+\frac{1}{1-x}$ (D) $\frac{x}{(1+x^2)^2}+\frac{1}{1-x}$

Key: (A)

Sol: $1,2,1,4,1,6,1,8,1,10\ldots\infty$

$$=1.x^0+2x^1+1x^2+4x^3+1x^4+6x^3+1x^6+8x^7\ldots.$$

$$=\left(x^0+x^2+x^3+\ldots\right)+\left(2x\times 4x^3+6x^5+8x^7+\ldots\right)$$

$$=\frac{x+x^3}{(1-x^2)^2}+\frac{1}{1-x}$$

37. Consider a simple undirected unweighted graph with at least three vertices. If A is the adjacency matrix of the graph, then the number of 3-cycles in the graph is given by the trace of

(A) A^3 (B) A^3 divided by 2

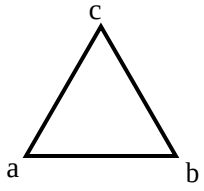
(C) A^3 divided by 3 (D) A^3 divided by 6

Key: (D)

Sol: Take a triangle as a graph, Find A^3. Trace will be 6 but there is only one cycle (triangle).

$$A = \begin{array}{c} \\ a \\ b \\ c \end{array}\begin{array}{c} \begin{array}{ccc} a & b & c \end{array} \\ \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} \end{array}$$

$$A^3 = \begin{bmatrix} 2 & 3 & 3 \\ 3 & 2 & 3 \\ 3 & 3 & 2 \end{bmatrix}$$



38. Which one of the following statements is FALSE?

(A) The TLB performs an associative search in parallel on all its valid entries using page number of incoming virtual address.

(B) If the virtual address of a word given by CPU has a TLB hit, but the subsequent search for the word results in a cache miss, then the word will always be present in the main memory.

(C) The memory access time using a given inverted page table is always same for all incoming virtual addresses.

(D) In a system that uses hashed page tables, if two distinct virtual addresses V1 and V2 map to the same value while hashing, then the memory access time of these addresses will not be the same.

Key: (C)

Sol: "The memory access time using a given inverted page table is always same for all incoming virtual addresses." : False

39. Let $R_i(z)$ and $W_i(z)$ denote read and write operations on a data element z by a transaction T_i, respectively. Consider the schedule S with four transactions

S : $R_4(x)R_2(x)R_3(x)R_1(y)W_1(y)W_2(x)W_3(y)R_4(y)$

Which one of the following serial schedules is conflict equivalent to S?

(A) $T_1 \to T_3 \to T_4 \to T_2$ (B) $T_1 \to T_4 \to T_3 \to T_2$

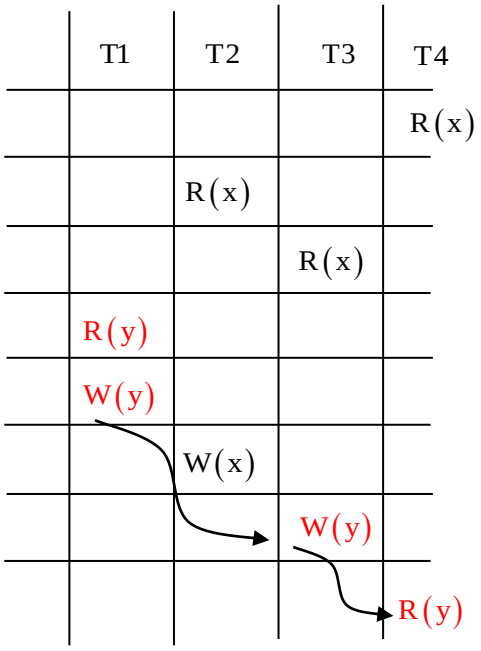
(C) $T_4 \to T_1 \to T_3 \to T_2$ (D) $T_3 \to T_1 \to T_4 \to T_2$

Key: (A)

Sol:

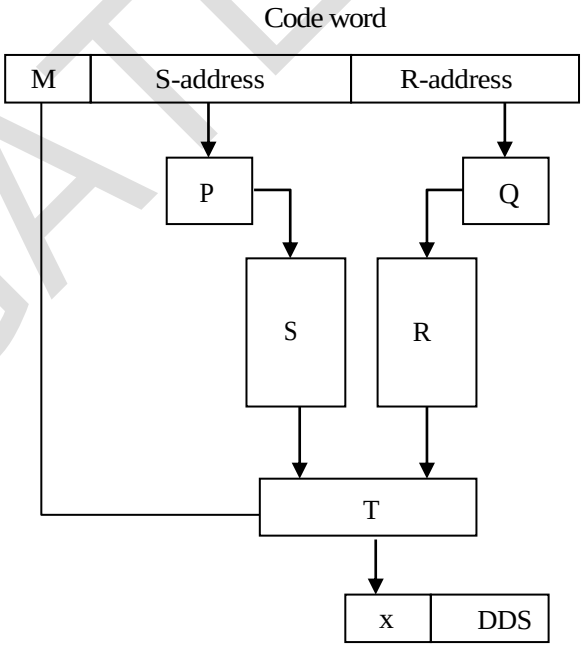
	T1	T2	T3	T4
				R(x)
		R(x)		
			R(x)	
	R(y)			
	W(y)			
		W(x)		
			W(y)	
				R(y)

If we draw dependency using conflict operation on above table



Then it is very clear that T1-> T3-> T4 order must be followed. Hence option A

40. Consider a digital display system (DDS) shown in the figure that displays the contents of register X. A 16-bit code word is used to load a word in X, either from S or from R. S is a 1024-word memory segment and R is a 32-word register file. Based on the value of mode bit M, T selects an input word to load in X. P and Q interface with the corresponding bits in the code word to choose the addressed word. Which one of the following represents the functionality of P, Q, and T?



(A) P is 10:1 multiplexer; Q is 5:1 multiplexer; T is 2:1 multiplexer

(B) P is $10:2^{10}$decoder; Q is $5:2^5$decoder ; T is 2:1 encoder

(C) P is $10:2^{10}$decoder; Q is $5:2^5$decoder ; T is 2:1 multiplexer

(D) P is 1: 10de-multiplexer; Q is 1:5de-multiplexer ; T is 2:1 multiplexer

Key: (C)

Sol: For T, there is a select line, input lines and output lines shown in the diagram.

There are no select lines associated with P and Q (only input and output lines shownin diagram)

Therefore P and Q are neither Multiplexers nor De-Multiplexers.
Those can be Decoders and T is Multiplexer of size 2x1

41. Consider three floating point numbers A, B and C stored in registers R_A, R_B and RC, respectively as per IEEE-754 single precision floating point format. The 32-bit content stored in the registers (in hexadecimal form) are as follows.

$R_A = 0 \times C1400000$	$R_B = 0 \times 42100000$	$R_C = 0 \times 41400000$

Which one of the following is FALSE?

(A) A + C = 0 (B) C = A + B (C) B = 3C (D) (B – C) > 0

Key: (B)

Sol: Given that numbers are in IEEE-754 single precision.

Representation :: 1 sign bit, 8 exponent bits and 23 Mantissa Bits

$$\text{Decimal value} = (-1)^{\text{Sign bit}} \times (1.\text{Mantissa}) \times (2)^{\text{exponent}-127}$$

$$R_A = 0xC1400000 = 1100\ 0001\ 0100\ 0000\ 0000\ 0000\ 0000$$

$$R_A = 0xC1400000 = \ 1\ \underbrace{100\ 0001\ 0}\underbrace{100\ 0000\ 0000\ 0000\ 0000\ 0000}$$

$$\text{Decimal value f } R_A - (-1)^1 \times (1.10000000000..) \times (2)^{130-127} = -(1100)_2 = -12$$

$$R_B = 0x42100000 = 0100\ 0001\ 0001\ 0000\ 0000\ 0000\ 0000\ 0000$$

$$R_B = 0x42100000 = \ 0\ \underbrace{100\ 0010\ 0}\underbrace{001\ 0000\ 0000\ 0000\ 0000\ 0000}$$

$$\text{Decimal value f } R_B = (-1)^0 \times (1.001000000000..) \times (2)^{132-127} = -(100100)_2 = 36$$

$$R_C = 0x41400000 = 0100\ 0001\ 0100\ 0000\ 0000\ 0000\ 0000\ 0000$$

$$R_C = 0x41400000 = \ 0\ \underbrace{100\ 0010\ 0}\underbrace{100\ 0000\ 0000\ 0000\ 0000\ 0000}$$

$$\text{Decimal value of } R_C = (-1)^0 \times (1.1000000000..) \times (2)^{130-127} = -(1100)_2 = 12$$

$\therefore C = A + B$ is false.

42. Consider four processes P, Q, R, and S scheduled on a CPU as per round robin algorithm with a time quantum of 4 units. The processes arrive in the order P, Q, R, S, all at time t = 0. There is exactly one context switch from S to Q, exactly one context switch from R to Q, and exactly two context switches from Q to R. There is no context switch from S to P. Switching to a ready process after the termination of another process is also considered a context switch. Which one of the following is NOT possible as CPU burst time (in time units) of these processes?

(A) P = 4, Q = 10, R = 6, S = 2
(B) P = 2, Q = 9, R = 5, S = 1
(B) P = 4, Q = 12, R = 5, S = 4
(D) P = 3, Q = 7, R = 7, S = 3

Key: (D)

Sol: Verify each option one by one, Option D is Not possible.

43. What is printed by the following ANSI C program?

```
#include <stdio. h>
int main(int argc, char *argv[])
{
      int a[3][3][3] =
      {{1, 2, 3, 4, 5, 6, 7, 8, 9},
      {10, 11, 12, 13, 14, 15, 16, 17, 18},
      {19, 20, 21, 22, 23, 24, 25, 26, 27}};
int i = 0, j = 0, k = 0;
for( i = 0; i <3; i++ ){
for(k = 0; k< 3; k++ )
printf("%d ", a[i][j][k]);
printf("\n");
}
return 0;
}
```

(A)
```
1 2 3
10 11 12
19 20 21
```

(B)
```
1 4 7
10 13 16
19 22 25
```

(C)
```
1   2   3
4   5   6
7   8   9
```

(D)
```
1   2   3
13  1415
25  2627
```

Key: **(A)**

Sol: i = 0, j = 0, output = 1,2,3

i = 1, j = 0, output = 10,11,12

i = 2, j = 0, output = 19,20,21

44. What is printed by the following ANSI C program?

```
# include <stdio.h>
Int main (int argc, char *argv[ ]) {
char  a  =  'P';
char  b   =   'x';
char  c   =  (a & b) + '*';
char  d   =  (a | b) - '-';
char  e  =  (a ^ b) + '+';
printf ("%c  %c  %c\n",  c, d, e) ;
return 0;
}
```

ASCII encoding for relevant characters is given below

A	B	C	⋯	Z
65	66	67	…	90

a	b	c	⋯	z
97	98	99	…	122

*	+	–
42	43	45

(A) z K S (B) 122 75 83 (C) * - + (D) P X +

Key: **(A)**

Sol: ASCII value of ‘P’ is 80, inn binary = 0101 0000

ASCII value of ‘x’ is 120, inn binary = 0111 1000

a = ‘P’

b = ‘x’

a^b is some nonzero value thats whychar e = (a^b) + ‘+’;e can not be ‘+’. Only option A matches.

45. Consider solving the following system of simultaneous equations using LU decomposition.

$x_1 + x_2 - 2x_3 = 4$
$x_1 + 3x_2 - x_3 = 7$
$2x_1 + x_2 - 5x_3 = 7$

Where L and U are denoted as

$$L = \begin{pmatrix} L_{11} & 0 & 0 \\ L_{21} & L_{22} & 0 \\ L_{31} & L_{32} & L_{33} \end{pmatrix} \quad U = \begin{pmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U \\ 0 & 0 & U_{33} \end{pmatrix}$$

Which one of the following is the correct combination of values for L_{32}, U_{33}, and x_1?

(A) $L_{32} = 2,\ U_{33} = -\frac{1}{2}, x_1 = -1$

(B) $L_{32} = 2,\ U_{33} = 2, x_1 = -1$

(C) $L_{32} = -\frac{1}{2}, U_{33} = 2, x_1 = 0$

(D) $L_{32} = -\frac{1}{2},\ U_{33} = -\frac{1}{2},\ x_1 = 0$

Key: (D)

Sol:

Row operations	LU
Initial matrix	$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \boxed{1} & 1 & -2 \\ 1 & 3 & -1 \\ 2 & 1 & -5 \end{bmatrix}$
$R2 - (1)R1 \to R2$ Subtract 1 row 1 from row 2 $U[2][1] = 1 - \frac{(1*1)}{1} = 0$ $U[2][2] = 3 - \frac{(1*1)}{2} = 2$ $U[2][3] = 1 - \frac{(1*-2)}{1} = 1$ $L[1][1] = 1$	$\begin{bmatrix} 1 & 0 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \boxed{1} & 1 & -2 \\ 0 & 2 & 1 \\ 2 & 1 & -5 \end{bmatrix}$

$R3-(2)R1 \rightarrow R3$ Subtract 1 row 1 from row 3 $U[3][1]=2-\frac{(2*1)}{1}=0$ $U[3][2]=1-\frac{(2*1)}{1}=2$ $U[3][3]=-5-\frac{(2*-2)}{1}=-1$ $L[3][1]=2$	$\begin{bmatrix}1&0&0\\1&1&0\\2&0&1\end{bmatrix}\begin{bmatrix}1&1&-2\\0&\boxed{2}&1\\0&-1&-1\end{bmatrix}$
$R3-\left(\frac{-1}{2}\right)R2->R3$ Subtract 2 row 2 from row 3 $U[3][2]=-1-\frac{(-1*2)}{2}=0$ $U[3][3]=-1-\frac{(-1*1)}{2}=\frac{-1}{2}$ $U[3][2]=\frac{-1}{2}$	$\begin{bmatrix}1&0&0\\1&1&0\\2&\frac{-1}{2}&0\end{bmatrix}\begin{bmatrix}1&1&-2\\0&2&1\\0&0&\frac{-1}{2}\end{bmatrix}$

46. Which of the following is/are undecidable?

(A) Given two Turing machines M_1 and M_2, decide if $L(M_1) = L(M_2)$.

(B) Given a Turning machine M, decide if L(M) is regular.

(C) Given a Turning machine M, decide if M accepts all strings.

(D) Given a Turing machine M, decide if M takes more than 1073 steps one every string.

Key: (A, B, C)

Sol: Option A,B,C are standard undecidable problems for turing machines.

Option 1 is the "Equivalence Problem of Turing Machines" which is standardundecidable problem.

Option 2 is the "Regularity Problem of Turing Machines" which is standardundecidable problem.

Option 3 is the "Universaility/Completeness Problem of Turing Machines" which isstandard undecidable problem.

Problem in option D is decidable. For every string, M will run 1073 steps on stringswhose length less than 1073 and decide it. However whose string length is morethan 1073, obviously takes more than 1073 steps.

47. Consider the following languages :

$L_1 = \{a^n w a^n \mid w \in \{a,b\}^*\}$

$L_2 = \{wxw^R \mid w,x \in \{a,b\}^*, |w|, |x| > 0\}$

Note that w^R is the reversal of the string w. Which of the following is / are TRUE ?

(A) L_1 and L_2 are regular

(B) L_1 and L_2 are context-free

(C) L_1 is regular and L_2 is context-free

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

Key: (A, B, C)

Sol: In L1 since w is (a + b)*, we can always put n = 0 and L1, will be just (a + b)* So L1 is regular.

In L2 since x can take (a + b)* so it will include every alphabet except first and last alphabet so the language will just become set of strings that starts and ends with the same symbol, that is also regular.

From above two conclusion option A is correct.

Every regular language is also CFL from this option B and C is also correct. Option D is wrong.

Answer A, B, C.

48. Consider the following languages:

$L_1 = \{ww \mid w \in \{a,b\}^*\}$

$L_2 = \{a^n b^n c^m \mid m,n \geq 0\}$

$L_3 = \{a^m b^n c^n \mid m,n \geq 0\}$

Which of the following statements is/are FALSE ?

(A) L_1 is not context-free but L_2 and L_3 are deterministic context-free

(B) Neither L_1 not L_2 is context-free

(C) L_2, L_3 and $L_2 \cap L_3$ all are context-free

(D) Neither L_1 nor its complement is context-free

Key: (B, C, D)

Sol: $L_1 = \{ww \mid w \in \{a,b\}^*\}$

This language is not CFL but its complement is CFL. It is a Standard language.

So L1 is not Context free language but L1 complement is Context free language.

$L2 = \{a^n b^n c^m \mid m,n \geq 0\}$

L2 is DCFL

$L2 = \{a^m b^n c^n \mid m,n \geq 0\}$

L3 is DCFL

Now come to the options,

Option A is true as it is already explained L1 is not context free and L2 and L3 is deterministic context free.

Option B is false as it say L2 is not context free but L2 is context free.

Option C is false as $L2 \cap L3 = \{a^n b^n c^n \mid n >= 0\}$ which is not CFL as it is CSL.

Option D is false as it says L1 complement is not Context free language but it is context free language. So it is false as well.

49. Consider a simple undirected weighted graph G, all of whose edge weights are distinct. Which of the following statements about the minimum spanning trees of G is/are TRUE?

(A) The edge with the second smallest weight is always part of any minimum spanning tree of G.

(B) One or both of the edges with the third smallest and the fourth smallest weights are part of any minimum spanning tree of G.

(C) Suppose $S \subseteq V$ be such that $S \neq \phi$ and $S \neq V$. Consider the edge with the minimum weight such that one of its vertices is in S and the other in V\S. Such an edge will always be part of any minimum spanning tree of G.

(D) G can have multiple minimum spanning trees.

Key: (A, B, C)

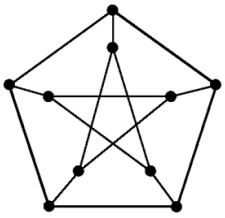
Sol: Option A: Kruskal's algo will always select 2nd smallest since it never forms a cycle

Option B: If 3rd smallest forms a cycle in kruskal then 4th won't. Hence one or both ofthem will be selected.

Option C: This is cut property of MST

Option D: False since every edge is distinct.

50. The following simple undirected graph is referred to as the Peterson graph.

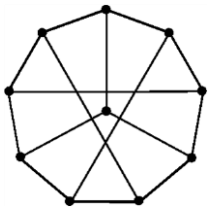


Which of the following statements is / are TRUE?

(A) The chromatic number of the graph is 3.

(B) The graph has a Hamiltonian path

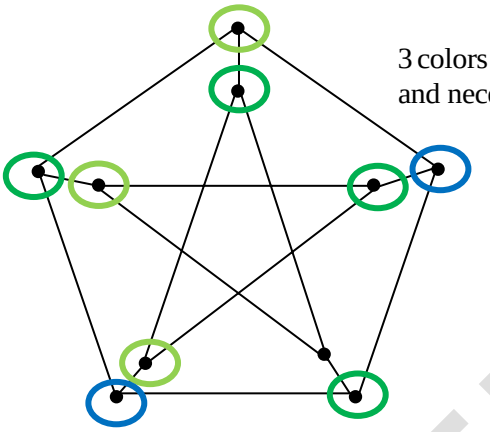
(C) The following graph is isomorphic to the Peterson graph.



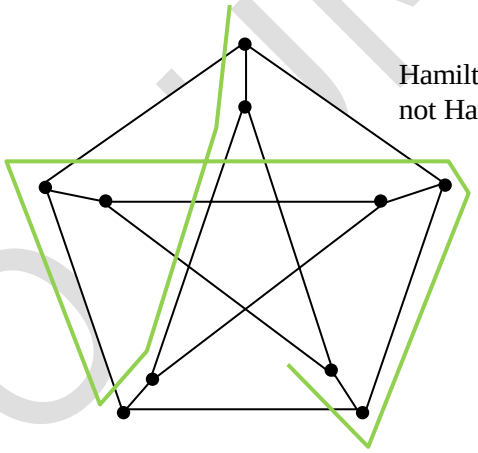
(D) The size of the largest independent set of the given graph is 3. (A subset of vertices of a graph form an independent set if no two vertices of the subset are adjacent.)

Key: (A, B)

Sol: Given graph is Peterson graph.



3 colors sufficient and necessary



Hamilton path exist but not Hamilton cycle

51. Consider the following recurrence:

$f(1) = 1;$

$f(2n) = 2f(n) - 1$, for $n \geq 1;$

$f(2n+1) = 2f(n) + 1$, for $n \geq 1.$

Then, which of the following statements is/are TRUE?

(A) $f(2^n - 1) = 2^n - 1$

(B) $f(2^n) = 1$

(C) $f(5.2^*) = 2^{n+1} + 1$

(D) $f(2^n + 1) = 2^n + 1$

Key: (A, B, C)

Sol: $f(1) = 1, [\text{Given}]$

$f(2) = f(2 \times 1) = 2f(1) - 1 = 2 \times 1 - 1 = 1$

$f(3) = f(2 \times 1 + 1) = 2 \times f(1) + 1 = 2 \times 1 + 1 = 3$

$f(4)=f(2\times 2)=2\times f(2)-1=2\times 1-1=1$

$f(5)=f(2\times 2+1)=2\times f(2)+1=2\times 1+1=3$

$f(6)=5$

$f(7)=f(2\times 3+1)=2f(3)+1=2\times 3+1=7$

$f(8)=1$

$f(9)=f(2\times 4+1)=2\times f(4)+1=2\times 1+1=3$

$f(10)=5$

52. Which of the properties hold for the adjacency matrix A of a simple undirected unweighted graph having n vertices?

(A) The diagonal entries of A^2 are the degrees of the vertices of the graph.

(B) If the graph is connected, then none of the entires of $A^{n-1} + I_n$ can be zero.

(C) If the sum of all the elements of A is at most 2(n – 1), then the graph must be acyclic.

(D) If there is at least a 1 in each of A's rows and columns, then the graph must be connected.

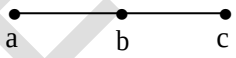
Key: (A)

Sol: $A^n(ij)$ represents the number of walks of length n from *i* to *j* in the graphG.

Option A: Diagonal entry in A^2 means : number of length 2 from any vertex to itself. Itmeans we start from i and go to j, then we go back to i from j. This is a walk of length 2.

And the total number of walks will be degrees of i.

Option B: see counter example below

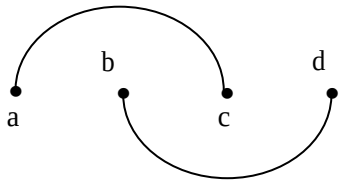


$$A=\begin{array}{c} \\ a \\ b \\ c \end{array}\begin{array}{c} \begin{array}{ccc} a & b & c \end{array} \\ \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} \end{array}$$

$$A^2=\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}=\begin{bmatrix} 1 & 0 & 1 \\ 0 & 2 & 0 \\ 1 & 0 & 1 \end{bmatrix}$$

Option C: we can have a disconnected graph where one of the component has cycle.

Option D: See counter example below



53. Which of the following is / are the eigen vector(s) for the matrix given below ?

$$\begin{pmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{pmatrix}$$

(A) $\begin{pmatrix} -1 \\ 1 \\ 0 \\ 1 \end{pmatrix}$ (B) $\begin{pmatrix} 1 \\ 0 \\ -1 \\ 0 \end{pmatrix}$ (C) $\begin{pmatrix} -1 \\ 0 \\ 2 \\ 2 \end{pmatrix}$ (D) $\begin{pmatrix} 0 \\ 1 \\ -3 \\ 0 \end{pmatrix}$

Key: (A, C, D)

54. Consider a system with 2 KB direct mapped data cache with a block size of 64 bytes. The system has a physical address space of 64 KB and a word length of 16 bits. During the execution of a program, four data words P, Q, R, and S are accessed in that order 10 times (i.e., PQRSPQRS…). Hence, there are 40 accesses to data cache altogether. Assume that the data cache is initially empty and no other data words are accessed by the program. The addresses of the first bytes of P, Q, R, and S are 0xA248, 0xC28A, 0xCA8A, and 0xA262, respectively. For the execution of the above program, which of the following statements is/are TRUE with respect to the data cache?

(A) Every access to S is a hit.

(B) Once P is brought to the cache it is never evicted.

(C) At the end of the execution only R and S reside in the cache.

(D) Every access to R evicts Q from the cache.

Key: (A, B, D)

Sol: Physical memory = 64 KB $\Rightarrow$ 16 bits required to represent Physical memory.

Cache memory = 2KB $\Rightarrow$ 11 bits for cache memory

Block size = 64 B= 32 words $\Rightarrow$ 6 bits because of system is Byte addressable.

Tag = 16 – 11 = 5 bits

Cache index = 11 – 6 = 5 bits

Block offset = 6 bits

P = 0 × 4A248 = 1010 0010 0100 1000 = 10100 01001 001000 (Tag – cache index – Block offset)

Q = 0 × C28A = 1100 0010 1000 1010 = 11000 01010 001010

R = 0 × CA8A = 1100 1010 1000 1010 = 11001 01010 001010

S = 0 × A262 = 1010 0010 0110 0010 = 10100 01001 100010

Given that, Direct mapped cache,

If we observe, P and S are belongs to same Block (Tag and cache bits are same). Therefore every access of S should result in a hit due to neither Q nor R completing for the same ache block and once P brought to the cache, it is never evicted.

If we observe Q and R, those are competing for same cache block. So at the end R only present in the cache due to R is accessed at last. (Comparing to Q) and every access to R evicts Q from the cache.

Therefore at the end, P, R and S in the cache.

Options A, B, and D areture.

55. Consider routing table an organization's router shown below ;

Subnet Number	**Subnet Mask**	**Next Hop**
12.20.164.0	255.255.252.0	R1
12.20.170.0	255.255.254.0	R2
12.20.168.0	255.255.254.0	Interface 0
12.20.166.0	255.255.254.0	Interface 1
Default		R3

Which of the following prefixes in CIDR notation can be collectively used to correctly aggregate all of the subnets in the routing table?

(A) 12.20.164.0/20 (B) 12.20.164.0/22 (C) 12.20.164.0/21 (D) 12.20.168.0/22

Key: (B, D)

Sol: Net1: 12.20.164.0/22=12.20.10100100.0

Net2: 12.20.170.0/23=12.20.10101010.0

Net3: 12.20.168.0/23=12.20.10101000.0
Net4: 12.20.166.0/23=12.20.10100110.0
Net4 is already part of Net1 which is option B.
Net2 and Net3 can be combined to 12.20.168.0/22 which is option D.

56. Consider the relational database with the following four schemas and their respective instances.

Student (sNo, sName, dNo) Dept (dNo, dName)

Course (cNo, cName, dNo) Register (sNo, cNo)

Student		
sNo	sName	dNo
S01	James	D01
S02	Rocky	D01
S03	Jackson	D02
S04	Jane	D01
S05	Milli	D02

Dept	
dNo	dName
D01	CSE
D02	EEE

Course		
cNo	cName	dNo
C11	DS	D01
C12	OS	D01
C21	DE	D02
C22	PT	D02
C23	CV	D03

Register	
sNo	cNo
S01	C11
S01	C12
S02	C11
S03	C21
S03	C22
S03	C 23
S04	C11
S04	C12
S05	C11
S05	C21

SQL Query:

SELECT * FROM Student AS S WHERE NOT EXIST

(SELECT cNo FROM Course WHERE dNo = "D01"

EXCEPT

SELECT cNo FROM Register WHERE sNo = S.sNo)

The number of rows returned by the above SQL query is_____.

Key: (2)

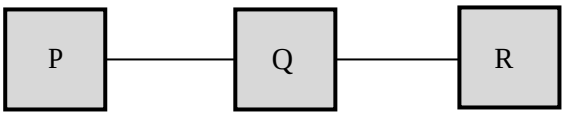
Sol: Given that correlated query,

Query returning the tuples from S where students who're registered with all the courses which are associated with D01 department.

By seeing the relation instances, we can understand that only two students from S (S01 and S04) , registered with all the courses which are associated with D01 department.

Therefore Query will return 2 tules from S.

57. Consider a network with three routers P, Q, R shown in the figure below. All the links have cost of unity.



The routers exchange distance vector routing information and have converged on the routing tables, after which the link Q−R fails. Assume that P and Q send out routing updates at random times, each at the same average rate. The probability of a routing loop formation *(rounded off to one decimal place)* between P and Q, leading to count-to-infinity problem, is_____.

Key: (0.5)

Sol: Explanation: After Q-R fails, Q will update its distance to R as ∞.

Now, it depends on P or Q - if P sends its vector first then there will be a problem ofcount to infinity.Since both have the same average rate of sending vectors (given in question) that's whythe probability that P sends first is $\frac{1}{2}$.

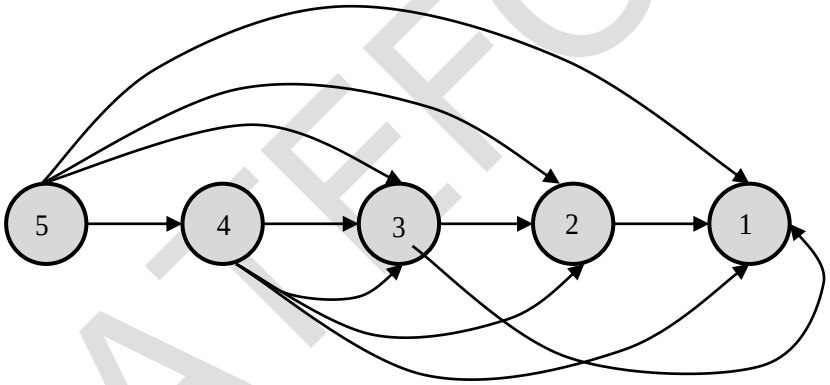
58. Let G(V,E) be a directed graph, where V = {1,2,3,4,5} is the set of vertices and E is the set of directed edges, as defined by the following adjacency matrix A.

$$A[i][j] = \begin{cases} 1, & 1 \le j \le i \le 5 \\ 0, & \text{otherwise} \end{cases}$$

A[i][j] = 1 indicates a directed edge from node i to node j. A directed spanning tree of G, rooted at $r \in V$, is defined as a subgraph T of G such that the undirected version of T is a tree, and T contains a directged path from r to every other vertex in V. the number of such directed spanning trees rooted at vertex 5 is _____.

Key: (24)

Sol: We have directed acyclic graph as follow as



We want rooted spanning trees. Root is fixed as 5.

Every permutation (starting from 5 as fixed) leads to one of the spanning trees.

Since there are 4 numbers apart from 5 hence 4! = 24 is the answer.

59. Consider a 100 Mbps link between an earth station (sender) and a satellite (receiver) at an altitude of 2100 km. The signal propagates at a speed of 3×10^8 m/s. The time taken (in milliseconds, rounded off to two decimal places) for the receiver to completely receive a packet of 1000 bytes transmitted by the sender is_____.

Key: (7.08)

Sol: $T_p = \frac{L}{BW} = \frac{8000}{100 \times 10^6} = 0.08 \text{ ms}$

$T_t = \frac{d}{v} = \frac{2100 \times 10^3}{3 \times 10^8} = 7 \text{ ms}$

$T_t + T_p = 7.08 \text{ ms}$

60. Consider the data transfer using TCP over a 1 Gbps link. Assuming that the maximum segment lifetime (MSL) is set to 60 seconds, the minimum number of bits required for the sequence number field of the TCP header, to prevent the sequence number space from wrapping around during the MSL is_____.

Key: (33)

Sol: We need a sequence number that can survive for 60 sec as 60 sec is MSL.

In 60 secs, we can send 1Gbps × 60sec = 60 Gb of data.

TCP is a byte oriented protocol, so we need to number every byte.

$60\text{Gb} = \frac{60}{8}\text{GB} = \frac{60 \times 2^{30}}{8}\text{B} = \frac{15 \times 2^{30}}{2}\text{B}$

$\text{ceil}\left(\log \frac{15 \times 2^{30}}{2}\right) = 33$

61. A processor X_1 operating at 2 GHz has a standard 5-stage RISC instruction pipeline having a base CPI (cycles per instruction) of one without any pipeline hazards. For a given program P that has 30% branch instructions, control hazards incur 2 cycles stall for every branch. A new version of the processor X_2 operating at same clock frequency has an additional branch predictor unit (BPU) that completely eliminates stalls for correctly predicted branches. There is neither any savings nor any additional stalls for wrong predictions. There are no structural hazards and data hazards for X_1 and X_2. If the BPU has a prediction accuracy of 80%, the speed up *(rounded off to two decimal places)* obtained by X_2 over X_1 in executing P is_____

Key: (1.4285)

Sol: Execution Time = Number of Instructions × Clocks per Instructions × Clock cycle time

$\text{Speedup} = \frac{\text{Old system execution time}}{\text{New system execution time}}$

When number of Instructions and clock time are same, then

$\text{Speedup} = \frac{\text{Old system CPI}}{\text{New system CPI}}$

Normal processor CPI = 1, without any pipeline hazards.

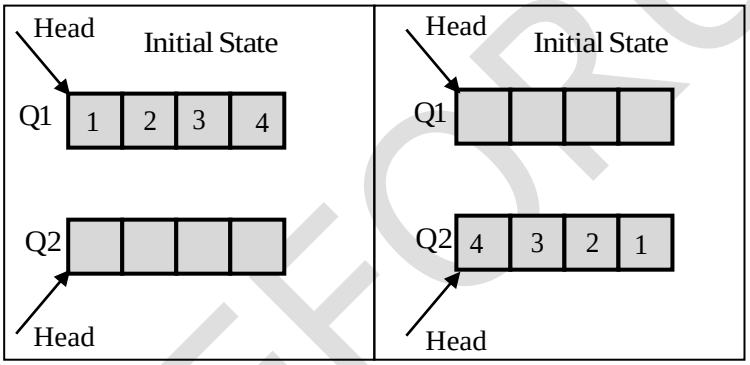
Given that, Program P has 30% branch instructions where each instruction will lead to 2 stall cycles.

Processor X1 has NO BPU, therefore $CPI = 1 + \overbrace{0.30 * 2}^{\text{branch instruction penalty}} = 1.60$

Processor X2 has BPU, therefore $CPI = 1 + \overbrace{\left(0.30 * \left(\underbrace{0.80 * 0}_{\text{BPU correctly predicted}} + \underbrace{0.2 * 2}_{\text{BPU wrongly predicted}}\right)\right)}^{\text{branch instructions penalty}} = 1.12$

$$\text{Speed up} = \frac{1.60}{1.12} = 1.4285$$

62. Consider the queues Q_1 containing four elements and Q_2 containing none (shown as the initial State in the figure). The only operations allowed on these two queues are Enqueue (Q, element) and Dequeue (Q). The minimum number of Enqueue operations on Q_1 required to place the elements of Q_1 in Q_2 in reverse order (shown as the final state in the figure) without using any additional storage is _____.



Key: (0)

Sol: We never need to enqueue anything in Q1. just dequeue from Q1 oneelement and put in Q2. Every time we put in Q2, we need to rearrange (enqueue Q2 anddequeue Q2) Q2 such that finally there are no enqueue to Q1 needed.

63. Consider two files systems A and B, that use contiguous allocation and linked allocation, respectively. A file of size 100 blocks is already stored in A and also in B. Now, consider inserting a new block in the middle of the file (between 50th and 51st block), whose data is already available in the memory. Assume that there are enough free blocks at the end of the file and that the file control blocks are already in memory. Let the number of disk accesses required to insert a block in the middle of the file in A and B are n_A and n_B, respectively, then the value of $n_A + n_B$ is _____.

Key: (153)

Sol: -No Free blocks-1, 2, 3, …49, 50, New Block, 51, 52, …99, 100, … Free blocks

Contiguous Allocation:

In case of Contiguous allocation we can directly go to the 50th element. After this, we have to insert a block here , and since the allocation is Contiguous, therefore you need to shift all the remaining 50

blocks to the right. [As enough free blocks are available to the right and no free blocks are available in the beginning. So we can only shift the blocks to the right only].

So, 50 Read Operations + 50 Write Operations + 1

[1 operation to write a newly inserted block] = 101 Operations in Total.

Also, we know from the Contiguous Memory allocation concept that overwriting an element simply means deleting it. Therefore, we don't have to worry about deleting an element specifically. We can just overwrite them, thus saving the cost of operations.

Linked Allocation:

In Linked Allocation, 50 operations to read first 50 elements, 2 operations are needed to delete the next pointer of the 50^{th} element, connect that link to the block which is to be the inserted, and then connect the next point of that block to the 51^{st} element. This takes 2 operations.

So, Total 52 operations are needed in this case.

64. Consider a demand paging system with four page frames (initially empty) and LRU page replacement policy. For the following page reference string

7,2,7,3,2,5,3,4,6,7,7,1,5,6,1

the page fault rate, defined as the ratio of number of page faults to the number of memory accesses (rounded off to one decimal place) is _____.

Key: (0.6)

Sol: Given page reference string

7, 2, 7, 3, 2, 5, 3, 4, 6, 7, 7, 1, 5, 6, 1

Given that four page frame in memory they are initially empty

Page replacement policy $\Rightarrow$ LRU replace those page which is least Recent

7	4	4	4	4	5
2	2	6	6	6	6
3	3	3	3	1	1
5	5	5	7	7	7
4M	1M	1M	1M	1M	1M

Total number of page fault = 4 + 1 + 1 + 1 + 1 + 1 = 9

Page fault rate = total number of PF/total references = 9/15 = 0.6

65. Consider the following grammar along with translation rules.

$S \rightarrow S_1 \# T \quad \{S.val = S_{1.val} * T.val\}$

$S \rightarrow T \quad \{S.val = T.val\}$

$T \rightarrow T_1 \% R \quad \{T.val = T_{1.val} \div R.val\}$

$T \rightarrow R \quad \{T.val = R.val\}$

$R \rightarrow id \quad \{R.val = id.val\}$

Her # and % are operators and id is a token that represents an integer and id.val represents the corresponding integer value. The set of non-terminals is {S,T,R,P} and a subscripted non-terminal indicates an instance of the non-terminal.

Using this translation scheme, the computed value of $S_{.val}$ for root of the parse tree for the expression 20#10%5#8%2%2 is _____.

Key: (80)

Sol: 20#10%5#8%2%2

=20∗(10÷5)∗((8÷2)÷2)

=20∗2∗2

=80