CLASS TEST

S.No.: 01 JP_CS_10102025

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COMPUTER SCIENCE & IT

Operating System, Theory of Computation, Compiler, DBMS, Algorithm, Computer Org. & Architecture

Duration : 1:30 hr. **Maximum Marks : 100**

Read the following instructions carefully

1. This question paper contains **50** objective questions. Carry **2 marks** each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.1 Consider the following μ-program?

I_1 : MAR ← IR[Addr]
I_2 : MBR ← M[MAR]
I_3 : ALU ← MBR

Which of the following operation is performed by above μ-program?

(a) Instruction fetch
(b) Direct operand fetch
(c) Interrupt sub program initiation
(d) Indirect operand fetch

Q.2 Consider the following recurrence relation:

$$T(n) = \begin{cases} 1 \text{ if } n = 2 \\ \sqrt{n}\, T\left(\sqrt{n}\right) + n \text{ if } n > 2 \end{cases}$$

What is the time complexity of above recurrence relation?

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

Q.3 Consider a cache consisting of 128 blocks of 16 words each. Main memory has 64 K words and given main memory is 16 bit addressable. The difference between tag memory size of Associative Mapping and Direct Mapping is

(a) 512 bits (b) 456 bits
(c) 1024 bits (d) 896 bits

Q.4 Consider a machine with a byte addressable main memory of 256 MB, block size of 128 bytes and 8-way set associative cache of size 64 kB. If the address of one of the memory location AB01C23H accessed by the CPU. What are the tag field of the corresponding cache line is

(a) 101010110000000 (b) 101110100000
(c) 101010110000 (d) 101101010100000

Q.5 The maximum number of order in which element {1, 2, 3, 4, 5, 6, 7} where 4 is the root can be insert into an empty AVL binary search tree such no rotation need to perform are _____.

(a) 36 (b) 48
(c) 54 (d) 64

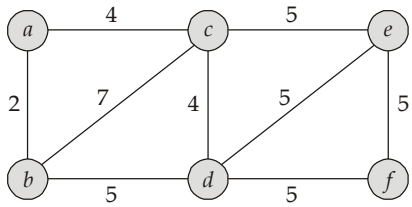
Q.6 Consider the following set of processes that need to be scheduled on a single CPU.

Process Name	Arrival Time	Burst Time
P_1	0	6
P_2	3	3
P_3	7	6
P_4	10	3

Assume all times are given in milliseconds and round robin CPU scheduling is used with time quantum 2 msec. The average turn around time is

(a) 7.75 msec (b) 7.89 msec
(c) 8.98 msec (d) 10.88 msec

Q.7 Consider the following graph:



Number of minimum spanning tree using Prim's or Kruskal's algorithm _____.

(a) 6 (b) 4
(c) 5 (d) 7

Q.8 A computer has 170 different operations. Word size is 4 bytes one word instructions requires two address fields. One address for register and one address for memory. If there are 37 registers then the memory size is

(a) 512 KB (b) 1024 KB
(c) 439 KB (d) 256 KB

Q.9 Consider the following recursive function find:

```
int find (int A[ ], int n)
{
    int sum = 0;
    if (n = = 0) return 0;
    sum = find (A, n – 1)
    if (A [n – 1] < 0) sum = sum + 1;
    return sum;
}
```

What is the worst case running time of above function find (A [ ], n) when array A has 0 to n – 1 elements?

(a) $O(1)$ (b) $O(\log n)$
(c) $O(n)$ (d) $O(n^2)$

Q.10 Consider the following statements about user level threads and kernel level threads.

S_1 : User level threads do not require hardware support.

S_2 : Blocking one kernel level thread can block all threads.

S_3 : User level threads are transparent to the kernel.

S_4 : User level threads are suitable for non blocking tasks.

Which statements are correct?

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

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

Q.11 Consider the following code:

```
Void main () {
...
for (int k = 1; k < 5; k ++)
pid [k] = fork ();
}
```

In the given code all for k( ) statements executed successfully and all pid variables initialized to 0. How many child processes created by the above code?

(a) 4 (b) 15

(c) 16 (d) 32

Q.12 Consider a 2-level paging system with TLB support. The page table has divided into 2 K pages each of size 8 K words. If the physical address space has 32 M words which is divided into 8K frame. TLB access time is 20 ns and main memory access time is 200 ns. The CPU finds 135 page reference in the TLB out of total reference of 180. Then what is the effective memory access time?

(a) 315 ns (b) 270 ns

(c) 220 ns (d) 320 ns

Q.13 Consider the following max-heap which is stored in the array.

55, 48, 51, 25, 18, 35, 24, 8, 19

Which of the following represent the max heap after one deletion?

(a) 55, 48, 35, 25, 18, 24, 19, 8

(b) 51, 48, 35, 25, 24, 18, 19, 8

(c) 51, 48, 35, 25, 18, 19, 24, 8

(d) 51, 48, 35, 25, 19, 18, 24, 8

Q.14 Consider a P-way set associative cache consisting of 128 lines with line offset of 64 words. Then number of TAG, set and words offset fields are 9, 5 and 6 bits respectively. If CPU generator 20 bits address of a word then value of P is _____.

(a) 2 (b) 4

(c) 8 (d) 16

Q.15 Consider the following table with weight of the items and their corresponding profit, Knapsack has capacity 50, the maximum profit that can be achieved through fractional Knapsack is using greedy algorithm _____.

Item	I_1	I_2	I_3	I_4	I_5
Weight	20	40	5	10	15
Profit	180	160	30	20	70

(a) 320 (b) 248

(c) 489 (d) 310

Q.16 Consider a recursive merge sort implementation that calls insertion sort on sublists which are smaller than some threshold, if there are n function calls in merge sort, how many calls will there be in insertion sort?

(a) $(n + 1)$

(b) $\log n$

(c) $\log n + n$

(d) $\left\lceil \frac{n}{2} \right\rceil$

Q.17 Which of the following is true?

(a) In write through protocol, cache location and main memory location are updated simultaneously.

(b) In write back protocol, cache location and main memory location are updated simultaneously.

(c) Modified or dirty bits are used by write through protocol.

(d) None of these

Q.18 Consider the following functions:

$$f_1 = n^4,\ f_2 = 4^n,\ f_3 = n^{110/37},\ f_4 = \left(\frac{119}{37}\right)^n$$

Which of the following is correct order of increasing growth rate?

(a) f_1, f_3, f_2, f_4 (b) f_3, f_1, f_4, f_2
(c) f_3, f_1, f_2, f_4 (d) f_1, f_3, f_4, f_2

Q.19 Consider a disk has 100 numbered from 0 to 99. At some time the disk arm is at cylinder 51 and there is a queue of disk access request for cylinders 16, 43, 46, 50, 55, 57, 73 and 83. If shortest seek time first (SSTF) is being used for scheduling disk access, the request for cylinder 55 is serviced after servicing the number of request

(a) 4 (b) 3
(c) 2 (d) 6

Q.20 Consider the following statements:

S_1: An advantage of aging is to solve starvation problem.

S_2: A thread running in critical section may get context switched.

Which of the above statements is true?

(a) S_1 only (b) S_2 only
(c) Both S_1 and S_2 (d) Neither S_1 nor S_2

Q.21 Which of the following statements is true?

(a) For a directed graph the absence of back edges in a DFS tree means the graph has no cycle.
(b) If all the edges in a graph have distinct weight then the shortest path between two vertices is unique.
(c) A complete graph with 4 vertices can have maximum 20 minimum cost spanning tree.
(d) Both (a) and (b)

Q.22 Suppose a CPU contains 1000 memory references there are 40 misses in L_1 cache (First Level Cache) and 20 misses in the L_2 cache (Second Level Cache). Assume miss penalty from the L_2 cache to memory is 100 clock cycles the hit time of L_2 cache is 10 clock cycles, the hit time of L_1 cache is 1 clock cycle.

What is the average memory access time?

(a) 3.4 clock cycles (b) 3.5 clock cycles
(c) 5.3 clock cycles (d) 1.8 clock cycles

Q.23 Consider the following program segment:

	Instruction	Meaning	Size (words)
I_1	LOAD r_0, 500	$r_0 \leftarrow [500]$	2
I_2	MOV r_1, r_0	$r_1 \leftarrow [r_0]$	1
I_3	ADD r_0, r_1	$r_0 \leftarrow r_0 + r_1$	1
I_4	INC r_0	$r_0 \leftarrow r_0 + 1$	1
I_5	INC r_1	$r_1 \leftarrow r_1 + 1$	1
I_6	ADD r_0, r_1	$r_0 \leftarrow r_0 + r_1$	1
I_7	Store r_1, r_0	$M[(r_1)] \leftarrow r_0$	2
I_8	Halt	Stop	1

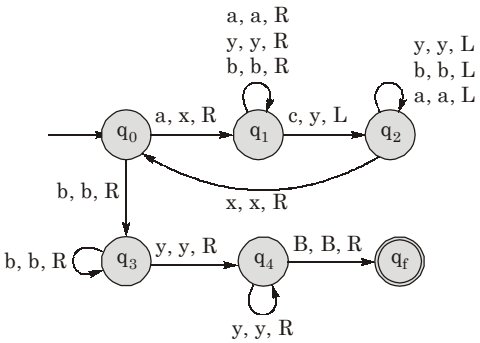
Assume that memory is word addressable with word size 32 bits. Program is loaded into memory location $(3001)_{10}$ onwards. The value of PC at the end of execution of above program is _____.

(a) 3010 (b) 3012
(c) 3014 (d) 3016

Q.24 What will be the maximum difference when quick sort is uses instead of heap sort for sorting the edge in the graph in Kruskal's algorithm for MST if number of edge is 128 _____.

(a) 16232 (b) 15488
(c) 18756 (d) 24863

Q.25 Consider the following TM:



Note: (a, b, c) represents: by reading input 'a', it replaces 'a' by 'b' and moves to 'c' direction. Which of the following language accepted by above TM?

(a) $\{a^m b^n c^k \mid m, n, k \geq 0, m = k\}$
(b) $\{a^m b^n c^k \mid m, n, k \geq 0, m = n\}$
(c) $\{a^m b^n c^k \mid m, n, k > 0, m = k\}$
(d) $\{a^m b^n c^k \mid m, n, k > 0, m = n\}$

Q.26 The running time of an algorithm is given by

$T(n) = T(n-1) + T(n-2) - T(n-3)$ if $n > 3$
n otherwise

What is the order of this algorithm?

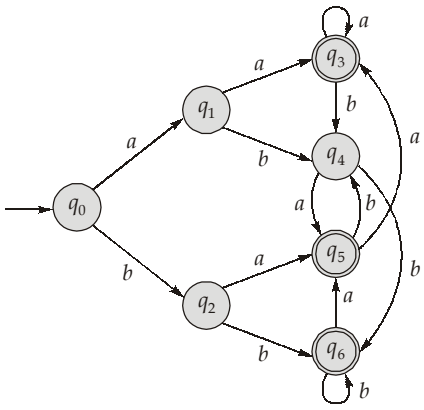
(a) O(log$n$) (b) O(n)
(c) O(n^2) (d) O(n^3)

Q.27 Consider a system uses 3 page frames for storing process pages in main memory. It uses the optimal replacement algorithm policy. Assume that all page frames are initially empty. The total number of page fault that will occur while processing is

5, 6, 7, 8, 6, 5, 10, 7, 6, 8, 10, 7

(a) 5 (b) 6
(c) 7 (d) 8

Q.28 Consider the DFA given below:



The minimum number of states needed for the equivalent DFA is _____.

(a) 4 (b) 5
(c) 6 (d) 7

Q.29 Considering the exponential average behaviour used to predict the next CPU burst. If $\alpha = 0.80$ and $\tau_0 = 25$ ms and previous (T_0, T_1, T_2, T_3) runs were as 10, 12, 15, 20. The predicted value of τ_4 is _____.

(a) 18.9 (b) 24.7
(c) 30.9 (d) 16.5

Q.30 Consider the following schedule:

S : $R_2(A)\ W_1(B)\ W_1(C)\ R_3(B)\ R_2(B)\ R_1(A)C_1$
$R_2(C)C_2\ W_3(A)C_3$

Which of the following is correct about above schedule?

(a) Schedule(S) is not conflict serializable schedule.
(b) Schedule(S) is allowed by 2PL.
(c) Schedule(S) is strict recoverable schedule.
(d) Schedule(S) is allowed by strict 2PL.

Q.31 Consider a 2-way set associative cache with 8 cache blocks. If the memory block requests are accessed 2 time in the following order 0, 4, 8, 4, 0, 4, 8, 4, 3, 15, 19, 15, 3, 15, 19, 15. If LRU replacement policy is used, then the total number of misses are _____.

(a) 12 (b) 14
(c) 16 (d) 18

Q.32 The length of the shortest string not in the language (over $\Sigma = \{0, 1\}$) for regular expression 1*(0 + 10)*1* is_____.

(a) 2 (b) 3
(c) 4 (d) None of these

Q.33 Consider the following SDT

$S \rightarrow S * S_1 \mid S_2$	$(S.val = S_1.val + S.val)$
$S_1 \rightarrow S_2$	$(S_1.val = S_2.val)$
$S_2 \rightarrow S_2 \# S_3$	$(S_2.val = S_2.val - S_3.val)$
$S_2 \rightarrow S_3$	$(S_2.val = S_3.val)$
$S_3 \rightarrow id$	$(S_3.val = id)$

Evaluate the expression 15 # 12 * 5 # 25 # 30 * 60

(a) 10 (b) 11
(c) 13 (d) 14

Q.34 Match the following errors corresponding to their phase:

Group A	Group B
1. Unbalanced parenthesis	**A.** Syntactic error
2. Appearance of illegal characters	**B.** Semantic error
3. Undeclared variables	**C.** Lexical error

(a) 1 → A, 2 → C, 3 → B
(b) 1 → B, 2 → C, 3 → A
(c) 1 → A, 2 → B, 3 → C
(d) 1 → B, 2 → C, 3 → A

Q.35 The following table has two attributes A and C where A is the primary key and C is the foreign key referencing A with on-delete cascade.

A	C
2	4
3	4
4	3
5	2
7	2
9	5
6	4

The number of tupples that must be additionally deleted to preserve referential integrity when the tupple (4, 3) is deleted is _____.

(a) 4 (b) 6
(c) 3 (d) 5

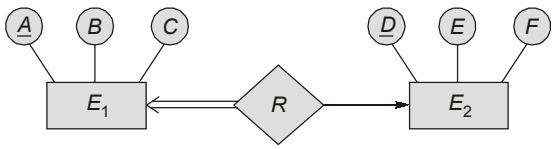
Q.36 Consider the following statements:

$\mathbf{S_1}$: $\{(a^n)^m \mid n \le m \ge 0\}$
$\mathbf{S_2}$: $\{a^n b^n \mid n \ge 1\} \cup \{a^n b^m \mid n \ge 1, m \ge 1\}$

Which of the following is regular?

(a) Only S_1 (b) Only S_2
(c) Both S_1 and S_2 (d) Neither S_1 nor S_2

Q.37 Consider the following ER model:



If 'n' entries in E_1 and 'm' entries in E_2. How many entries in relationship set (R)?

(a) At least n
(b) At most n
(c) Exactly n
(d) At least n and atmost m

Q.38 Consider the basic block given below:

$u = u + v$
$v = u - v$
$w = u + x$
$x = w \mid v$

The minimum number of nodes and edges present in the DAG representation of the above basic block respectively are:

(a) 6 and 10
(b) 6 and 6
(c) 5 and 7
(d) 5 and 8

Q.39 Consider L_1, L_2 be any deterministic context free language and L_3 be context free language and R be any regular language. Then which of the following is/are correct?

I. $L_1 \cup L_2$ is deterministic context free but not context free.
II. $L_1 \cap L_2$ is context sensitive.
III. $L_2 \cap L_3$ is context free.
IV. $L_3 \cap R$ is regular.

(a) I and II only
(b) II only
(c) III only
(d) IV only

Q.40 A database relation has 5000 records block can hold either 10 records or 15 keys and pointer pairs. If sparse index is used at 1st level and multilevel indexing is used in system, then the number of disk block required to store relation and index is _____.

(a) 569
(b) 568
(c) 538
(d) 432

Q.41 Consider A (P, Q, R, S, T, V, W) and the following FD's:

$W \to VS$
$T \to S$
$WS \to RT$
$QS \to P$

Which of the following is minimal cover of the given FD's?

(a) $\{W \to V, T \to S, W \to R, WS \to T, QS \to P\}$
(b) $\{W \to V, W \to S, T \to S, W \to R, QS \to P\}$
(c) $\{W \to V, T \to S, W \to R, WS \to R, QS \to P\}$
(d) $\{W \to V, T \to S, W \to R, W \to T, QS \to P\}$

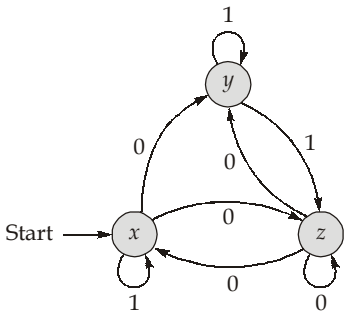
Q.42 Consider the following schedules:

T_1	T_2	T_3
$R(a)$		
	$R(a)$	
	$W(a)$	
		$W(b)$
		$W(a)$
$R(c)$		
$W(a)$		

Which of the following is correct about above schedule?

(a) Only view serializable
(b) Only conflict serializable
(c) Both conflict and view serializable
(d) Neither view serializable nor conflict serializable

Q.43 Consider the non-deterministic finite automation (NFA) shown in the figure:



Start x is the starting state of the automation. Let the language accepted by the NFA with y as the only accepting state be L_1. Similarly the language accepted by the NFA with z as the only accepting state be L_2. Which of the following statement about L_1 and L_2 is true?

(a) $L_1 = L_2$
(b) $L_2 \subset L_1$
(c) $L_1 \subset L_2$
(d) None of the above

Q.44 Consider a Push Down Automata (PDA) below which runs over the input alphabet (a, b). It has the stack alphabet $\{z_0, X\}$ where z_0 is the bottom of stack marker. The set of states of PDA is $\{q_0, q_1\}$ where q_0 is the start state.

$\delta\{q_0, b, z_0\} = \{(q_0, Xz_0)\}$
$\delta\{q_0, b, X\} = \{(q_0, XX)\}$
$\delta\{q_0, a, X\} = \{(q_1, X)\}$
$\delta\{q_0, \in, z_0\} = \{(q_0, \in)\}$
$\delta\{q_1, b, X\} = \{(q_1, \in)\}$
$\delta\{q_1, a, z_0\} = \{(q_0, z_0)\}$

The language accepted by PDA is

(a) $L = \{(b^n ab^n a)^m \mid m, n \geq 0\}$
(b) $L = \{(b^n ab^n a)^m \mid n, m \geq 0\} \cup \{b^n \mid n \geq 0\}$
(c) $L = \{(b^n ab^n)^m a \mid n, m \geq 0\}$
(d) None of the above

Q.45 If $L_1 = \{a^n b^n \mid n \geq 0\}$ and $L_2 = \{b^n c^n \mid n \geq 0\}$, consider

I. $L_1 \cdot L_2$ is non CFL
II. $L_1 \cdot L_2 = \{a^n b^{2n} c^n \mid n \geq 0\}$

Which one of the following is correct?

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

Q.46 Consider a pipeline processor with 5 stages, Instruction Fetch (IF). Instruction Decode and Operand Fetch (ID), Operation performed (OP). Data memory access (MA) and Write back (WB). The IF, ID, MA and WB stages takes 1 clock cycle each for any instruction. The OP stage takes 1 clock cycle for ADD and SUB instructions and takes 3 clock cycles for MUL instruction. The minimum number of clock cycles are needed to complete following sequence of instruction if operand forwarding is used

Instruction	**Meaning of Instruction**
I_0 : ADD R_2, R_0, R_1	$R_2 \leftarrow R_0 + R_1$
I_1 : SUB R_1, R_2, R_1	$R_1 \leftarrow R_2 + R_1$
I_2 : MUL R_2, R_1, R_0	$R_2 \leftarrow R_1 + R_0$
I_3 : SUB R_0, R_2, R_0	$R_0 \leftarrow R_2 + R_0$
I_4 : ADD R_3, R_1, R_0	$R_3 \leftarrow R_1 + R_0$

(a) 11
(b) 12
(c) 18
(d) 21

Q.47 Consider two concurrent process P and Q with shared variable a and b, two binary semaphore A and B is used which is initialized to 1.

Process P:
```
While (1)
{
    X1 ;
    X2 ;
    a = a + 2;
    b = b – 1;
    Signal (A);
    Signal (B);
}
```

Process Q:
```
While (1)
{
    X3 ;
    X4 ;
    b = b + 1;
    a = a – 3;
    Signal (B);
    Signal (A);
}
```

What is the value of X_1, X_2, X_3, X_4 respectively to satisfy mutual exclusion, progress and bounded waiting?

(a) Wait (B), wait (A), wait (A), wait (B)
(b) Wait (A), wait (B), wait (B), wait (A)
(c) Wait (A), wait (B), wait (A), wait (B)
(d) None of these

Q.48 Consider X, Y, Z are shared semaphores consider following three concurrent processes:

Process-1	**Process-2**	**Process-3**
Wait (X)	Wait (Y)	Wait (Z)
Wait (Z)	Print "B"	Wait (X)
Print "A"	Print "E"	Print "C"
Print "D"	Signal (X)	Print "F"
Signal (Y)	Signal (Z)	Signal (Y)
End	End	End

If on running these processes concurrently, possible outputs are:

1. CFBEAD 2. ACFDBE 3. ADCFBE

What can be the initial value of X, Y and Z so that above outputs are possible?

(a) $X = 2$, $Y = 0$ and $Z = 2$ (b) $X = 1$, $Y = 0$ and $Z = 1$
(c) $X = 2$, $Y = 0$ and $Z = 1$ (d) $X = 1$, $Y = 0$ and $Z = 2$

Q.49 Consider the following CFG:

$E \rightarrow A$
$A \rightarrow BC \mid DB\ C$
$B \rightarrow Bb \mid \in$
$C \rightarrow c \mid \in$
$D \rightarrow a \mid d$

What is the FIRST and FOLLOW set of nonterminal B?

(a) FIRST = {b, ∈}
FOLLOW = {b, c}
(b) FIRST = {b}
FOLLOW = {b, c, $}
(c) FIRST = {b}
FOLLOW = {b, $}
(d) FIRST = {b, ∈}
FOLLOW = {b,c, $}

Q.50 Consider a database that has the relation schemas;

student(ID, name, dept_name, tot_cred)

course(coures_id, dept_name)

takes(ID, coures_id, sec_id, semester, year, grade)

"Find all students who have taken all courses offered in the CS department". Which of the following will represents above queries?

(a) $\{t \mid \exists r \in \text{student } (r[\text{ID}] = t[\text{ID}]) \wedge (\forall u \in \text{course } (u[\text{dept\_name}] = \text{"CS"} \Rightarrow \exists s \in \text{takes } (t[\text{ID}] = s[\text{ID}] \wedge s[\text{course\_id}] = u[\text{course\_id}]))\}$

(b) $\{t \mid \exists r \in \text{student } (r[\text{ID}] = t[\text{ID}]) \wedge (\forall u \in \text{course } (u[\text{dept\_name}] \neq \text{"CS"} \vee \exists s \in \text{takes } (t[\text{ID}] = s[\text{ID}] \wedge s[\text{course\_id}] = u[\text{course\_id}]))\}$

(c) Both (a) and (b)

(d) None of these

■■■■

CLASS TEST

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DBMS | ALGO | COA

COMPUTER SCIENCE & IT

Date of Test : 10/10/2025

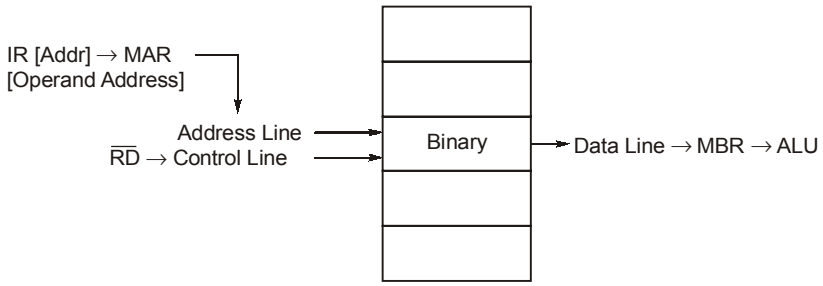
ANSWER KEY ➤

1.	(b)	11.	(b)	21.	(a)	31.	(d)	41.	(d)
2.	(a)	12.	(d)	22.	(a)	32.	(c)	42.	(d)
3.	(d)	13.	(c)	23.	(a)	33.	(c)	43.	(a)
4.	(a)	14.	(b)	24.	(b)	34.	(a)	44.	(a)
5.	(b)	15.	(a)	25.	(c)	35.	(b)	45.	(d)
6.	(a)	16.	(d)	26.	(b)	36.	(c)	46.	(a)
7.	(c)	17.	(a)	27.	(c)	37.	(c)	47.	(c)
8.	(d)	18.	(b)	28.	(b)	38.	(b)	48.	(a)
9.	(c)	19.	(b)	29.	(a)	39.	(b)	49.	(d)
10.	(c)	20.	(c)	30.	(b)	40.	(c)	50.	(c)

DETAILED EXPLANATIONS

1. (b)

In T_1 cycle content register goes to MAR i.e. address which contain actual data.
In T_2 cycle content of MAR i.e. actual data transferred to MBR.
In T_3 cycle content of MBR transferred ALU after the execution start.
So this μ-program represent direct operand fetch which is shown by below diagram.



2. (a)

$$T(n) = \sqrt{n}\,T\left(\sqrt{n}\right) + c \cdot n \qquad c \text{ is some constant}$$

$$= \sqrt{n}\left[n^{1/4}T(n^{1/4}) + c\sqrt{n}\right] + cn$$

$$= n^{3/4}\,T(n^{1/4}) + c \cdot n + c\,n \qquad k \text{ times}$$

$$= n^{1-1/2k}\,T(n^{1/2k}) + k\,c\,n$$

$$n^{1/2k} = 2$$

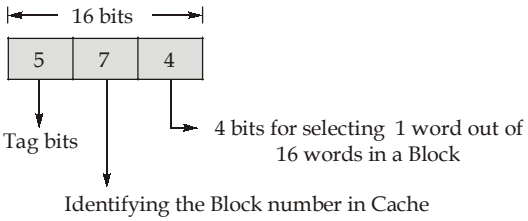
$$2^{2k} = n$$

$$2^k = \log n,\ k = \log\log n$$

$$T(n) = \theta(n\log\log n)$$

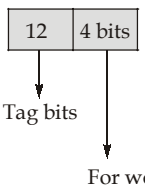
3. (d)

Direct Mapping



Tag memory = 5 × 128 blocks = 640 bits

Associative Mapping



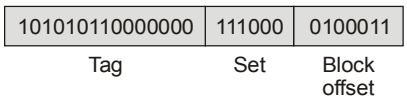
Tag memory = 12 × 128 blocks = 1536 bits

Tag memory size difference = 1536 – 640 = 896 bits

4. (a)

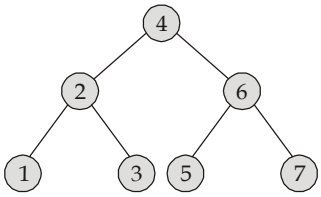
$$\text{Cache size} = 64\text{ kB} = 2^{16}$$
$$\text{Block size} = \text{Cache line size} = 128\text{ bytes} = 2^{7}$$
$$\text{Number of cache lines} = \frac{2^{16}}{2^{7}} = 2^{9}$$
$$\text{Number of sets} = \frac{2^{9}}{2^{3}} = 2^{6} = 64$$

Memory location : A B 0 1 C 2 3



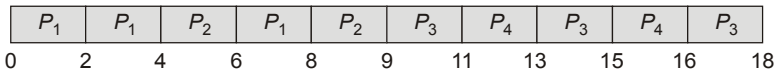
5. (b)

Given that 4 is the root of the tree and no rotation is performed.



There ordering of (2, 6) not matter total way = 2! = 2
(1, 3, 5, 7) can be come in any order 4! = 24.
Total maximum order possible = 24 × 2 = 48

6. (a)

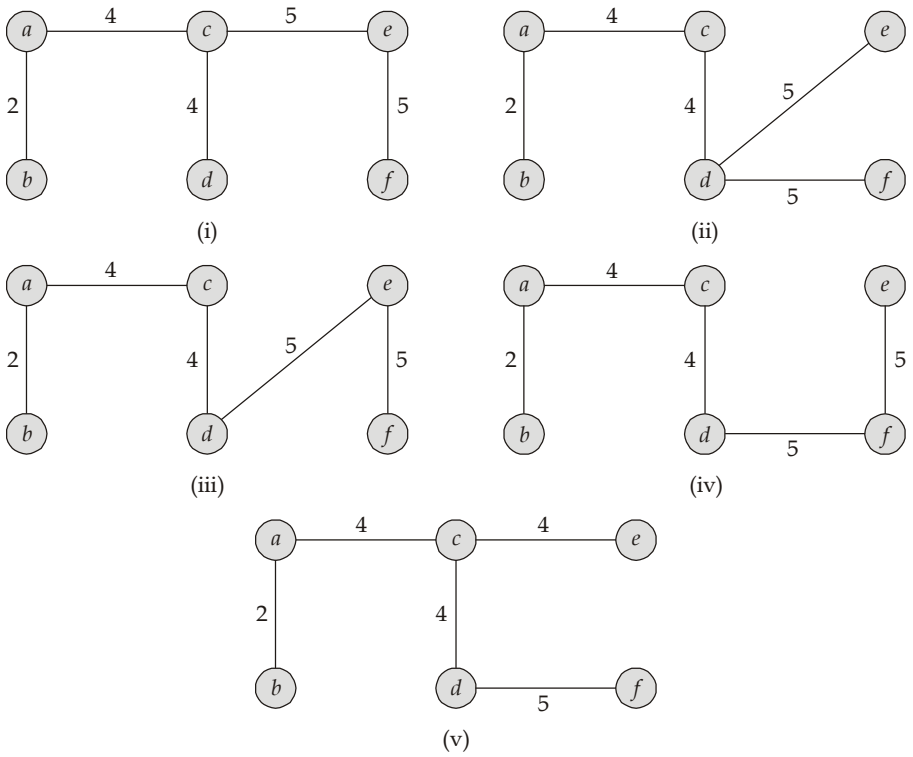


Process Name	Arrival Time	Exertion Time	Completion Time	TAT
P_1	0	6	8	8
P_2	3	3	9	6
P_3	7	6	18	11
P_4	10	3	16	6

$$\text{Average} = \frac{31}{4} = 7.75\text{ msec}$$

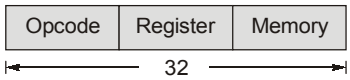
7. (c)

We get same number of spanning tree using Prim's or Kruskal's algorithm.



Total 5 minimum spanning tree exists.

8. (d)



$$\text{Opcode bit} = \lceil \log_2 170 \rceil = 8$$
$$\text{Register address bit} = \lceil \log_2 37 \rceil = 6$$
$$\text{Memory address bit} = 32 - (8 + 6) = 18$$
$$= 2^{18} \text{ cells}$$
$$= 256 \text{ K cells}$$
$$= 256 \text{ KB} = 256$$

9. (c)

Recurrence relation for the function find:

$$F(n) = 0; \text{ if } n = 0$$
$$= F(n - 1) + 1; \text{ if } n > 0$$

Time complexity of $F(n) = O(n)$

10. (c)

- User level threads are managed by thread library.
- For kernel level threads, it one thread blocks it doesn't cause entire process to block.
- Kernel level threads are not portable because the implementation is operating system dependent.

11. (b)

At each time, when for $k(\,)$ calls, the number of processes becomes doubled. So after 'n' for $k(\,)$, the total processes created will be 2^n, where out of 2^n, 1 process is parent process and $2^n - 1$ are child processes. So here for 4 for $k(\,)$ cells, child processes created is $2^n - 1 = 15$.

12. (d)

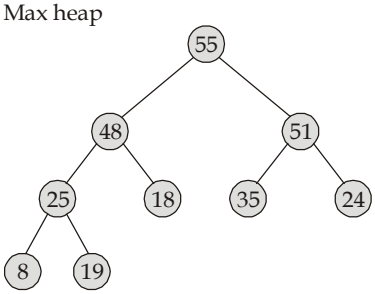
$$\text{TLB hit ratio } (x) = \frac{135}{180} = 0.75$$

Effective memory access time: $x(C + M) + (1 - x)(C + 3M)$

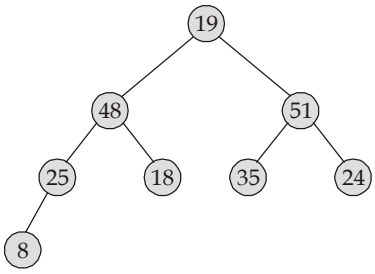
$= 0.75\ (20 + 200) + (1 - 0.75)\ (20 + 3(200)) = 165 + 155 = 320$ ns

13. (c)

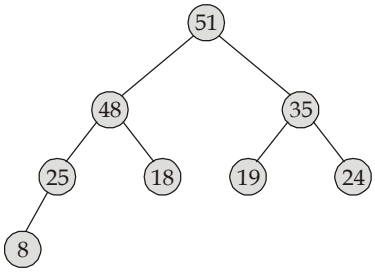
Max heap



On deletion perform the heapify operation and root will be deleted.

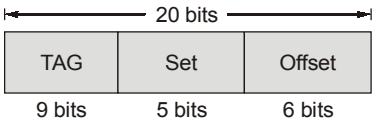


After performing heapify.



Max heap (51, 48, 35, 25, 18, 19, 24, 8).

14. (b)



$$\text{Number of Set} = \frac{\#\text{ lines}}{\text{P-way}} \quad \text{[Since 128 lines, so \# bits = 7]}$$

$$32 = \frac{2^7}{\text{P-way}}$$

$$\text{P-way} = \frac{2^7}{2^5} = 2^2 = 4$$

$$P = 4$$

15. (a)

Item	I_1	I_2	I_3	I_4	I_5
Weight / Profit	9	4	6	2	4.66

Items is descending profit/weight are I_1, I_3, I_5, I_2, I_4
First I_1, I_3, I_5 is chosen.

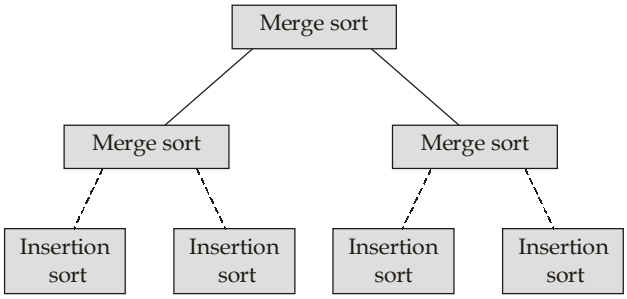
$$\text{Profit} = 180 + 30 + 70$$
$$\text{Weight} = 20 + 5 + 15 = 40$$
$$\text{Remaining weight } 50 - 40 = 10$$

Some fraction of I_2 is inserted in Knapsack

$$\text{Profit} = \frac{10 \times 160}{40} = 40$$
$$\text{Total profit} = 180 + 30 + 70 + 40 = 320$$

16. (d)

Consider merge sort in terms of full binary tree, each call to merge sort either result in two new calls to merge sort or a single call to insertion sort, the calls to insertion sort are equivalent to the leaf nodes of a full binary tree.



Number of leaf nodes in a full binary tree of n nodes is $\left\lceil \frac{n}{2} \right\rceil$, so $\left\lceil \frac{n}{2} \right\rceil$ calls to insertion sort.

17. (a)

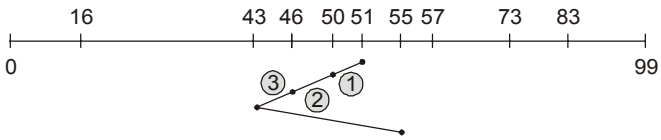
Write through protocol update cache and main memory simultaneously where write back first cache is updated and marked by dirty bit then main memory is updated.
Dirty bits are used by only write back protocol to know which cache block is updated.

18. (b)

$$f_1 = n^4 \text{ (polynomial time)}$$
$$f_2 = 4^n \text{ (ex-polynomial time)}$$
$$f_3 = n^{110/37} = n^{3.79} \text{ (polynomial)}$$
$$f_4 = (3.25)^n \text{ (exponential)}$$

$f_3 < f_1 < f_4 < f_2$

19. (b)



So service 55 is serviced after servicing 3 request.

20. (c)

S_1: Aging is used to solve starvation problem.

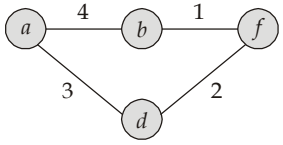
S_2: A thread running in user mode in critical section may get context switched.

Both S_1 and S_2 is true.

21. (a)

(a) For a directed graph if DFS tree does not have back edges then there is no cycle.

(b) Shortest path between two vertices may not be unique.



Shortest path between $a - f$ is not unique.

(c) A complete graph can have maximum $n^{n-2} = 4^{4-2} = 16$ MST.

So only option (a) is true.

22. (a)

Average Memory Access time

= Hit Time L_1 + Miss rate L_1 × (Hit time L_2 + Miss rate L_2 × Miss Penalty L_2)

$$= 1 + 4\% \ (10+50\% \times 100) \left[\text{Miss rate } L_1 = \frac{40}{1000} \times 100 = 4\%\right]$$

$$= 1 + 4\% \times 60 \left[\text{Miss rate } L_2 = \frac{20}{40} \times 100 = 50\%\right]$$

= 3.4 clock cycles

Alternate

T_{avg} = Hit time$_{L1}$ + (Miss rate$_{L1}$ * Miss penality$_{L1}$)

Miss penality$_{L1}$ = Hit time$_{L2}$ + (Miss rate$_{L2}$ * Miss penality$_{L2}$)

= 10 cycles + 50 cycles = 60 cycles

$$T_{avg} = \left(1 + \left(\frac{40}{1000} \times 60\right)\right) = 3.4 \text{ cycles}$$

23. (a)

Word addressable storage

3001 – 3002	→	I_1
3003	→	I_2
3004	→	I_3
3005	→	I_4
3006	→	I_5
3007	→	I_6
3008 – 3009	→	I_7
3010	→	I_8

Valid program counter value after program is 3010.

24. (b)

Time complexity of heap sort

$$= n\log n = E \log E$$
$$= 128 \log 128$$
$$= 128 \times 7 = 896$$

Time complexity of quick sort in worst case because we have to find maximum difference.

$$T(n) = n^2 = E^2$$
$$= (128)^2 = 16384$$
$$\text{Difference} = 15488$$

25. (c)

$$L = \{a^m b^n c^k \mid m, n, k > 0 \text{ and } m = k\}$$

Here, a's are replaced by x and c's are replaced by y in every scan from $q_0 \rightarrow q_1 \rightarrow q_2 \rightarrow q_0$

To reach final state, atleast one b should appear and atleast one y (y represents c hence a also must appear) should appear.

$\therefore$ $L = a^i b^j c^i \mid i, j > 0\}$ is accepted by TM

So option (c) is correct.

26. (b)

$$T(n) = T(n-1) + T(n-2) - T(n-3),\ n > 3$$
$$T(4) = T(3) + T(2) - T(1)$$
$$= 3 + 2 - 1 = 4$$
$$T(5) = T(4) + T(3) - T(2)$$
$$= 4 + 3 - 2 = 5$$

By induction

$$T(n) = T(n-1) + T(n-2) - T(n-3)$$
$$= (n-1) + (n-2) - (n-3) = n$$
$$T(n) = O(n)$$

27. (c)

5	6	7	8	6	5	10	7	6	8	10	7
		7	8	8	8	8	8	8	8	8	8
	6	6	6	6	6	6	6	6	6	10	10
5	5	5	5	5	5	10	7	7	7	7	7
M	M	M	M	H	H	M	M	H	H	M	H

28. (b)

Transition table for given DFA:

	a	b
q_0	q_1	q_2
q_1	q_3	q_4
q_2	q_5	q_6
(q_3)	q_3	q_4
q_4	q_5	q_6
(q_5)	q_3	q_4
(q_6)	q_5	q_6

$\Longrightarrow$

	a	b
q_0	q_1	q_2q_4
q_1	q_3	q_2q_4
(q_2q_4)	q_3q_5	q_6
(q_3q_5)	q_3q_5	q_2q_4
(q_6)	q_5	q_6

So, 5 states are needed for equivalent minimum states finite automata.

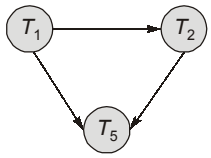
29. (a)

$$\tau_{n+1} = \alpha\, t_n + (1 - \alpha)\tau_n$$
$$\tau_1 = 0.8\ (10) + (0.2)\ (25) = 13$$
$$\tau_2 = 0.8\ (12) + (0.2)\ (13) = 12.2$$
$$\tau_3 = 0.8\ (15) + (0.2)\ (12.2) = 14.44$$
$$\tau_4 = 0.8\ (20) + (0.2)\ (14.44) = 18.999 \approx 19.0$$

30. (b)

T_1	T_2	T_3
	$S(A)$ $R_2(A)$	
$X(B)$ $W_1(B)$ $X(C)$ $W(C)$ $S(A)$ $U(A)$		
		$S(B)$ $R_3(B)$
	$S(B)$ $R_2(B)$	
$S(B)$ $R(A)$ $U(B)$ C_1		
	$R_2(C)$ $U(A)U(B)$ C_2	
		$X(A)$ $W_3(A)$ $U(B)U(A)$ C_3

(*i*) Conflict serializable

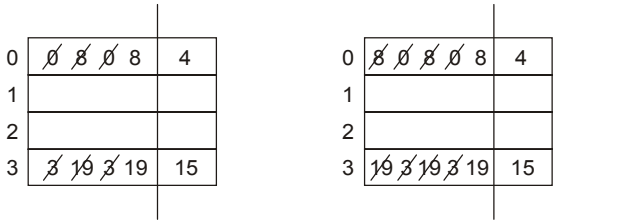


(*ii*) Allowed by 2PL.
(*iii*) Not strict recoverable.
(*iv*) No allowed by strict 2PL.

31. (d)

$$\text{Number of sets} = \frac{\text{Number of blocks}}{2}$$

$$= \frac{8}{2} = 4$$



1st access
[Initially all sets are empty]
Number of miss = 10

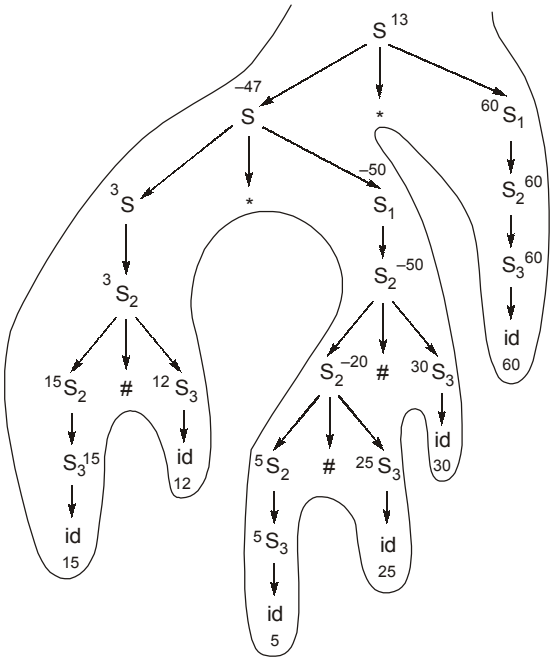
2nd access
[Initially set 1 contains 8, 4 and set 3 contains 19, 15]
Number of miss = 8

So, total number of misses are = 10 + 8 = 18

32. (c)

Check the string one by one starting from $\in$, 0, 1, 00, 01,... until we reach the first string that is not generated by the given regular expression. In this case, smallest string not generated by the given regular expression is '0110' whose length is 4.

33. (c)



34. (a)

(i) Errors like appearance of illegal characters, unmatched string comes under lexical phase errors.
(ii) Misspelled keywords, unbalanced parenthesis appear during syntax analysis phase of compiler.
(iii) Incompatible type of operands, undeclared variables detected during semantic analysis phase.

35. (b)

If (4, 3) is deleted then 4 is the primary key but in (2, 4), (6, 4) and (3, 4), 4 is the foreign key so these must be deleted.

The primary key for (2, 4), (3, 4) and (6, 4) is 2, 3 and 6 respectively must be deleted but in (5, 2) and (7, 2) with primary key 5 and 7 is the foreign key also deleted and (9, 5) is also deleted because 5 is primary key which is already deleted.

36. (c)

Put $n = 1$ in S_1 we get $\{(a^1)^m \mid 1 \le m\} \cup \{\in\}$

$= \{a^m \mid m \ge 0\} = a^*$

- Therefore S_1 is regular.
- S_2 represents $a^n b^n \cup a^+b^+ = a^+b^+$ which is regular. Hence regular.

37. (c)

Every object of E_1 must relate with atleast one entry of E_2.

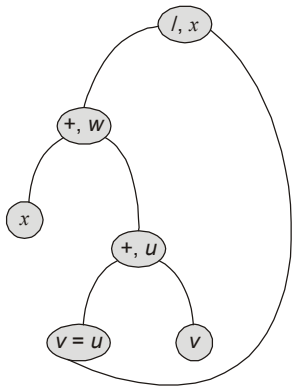
38. (b)

$u = u + v$

$v = u - v = u + v - v = u$

$w = u + x$

$x = w \mid v$



39. (b)

- $L_1 \cup L_2 = \text{DCFL} \cup \text{DCFL}$
  $= \text{CFL} \cup \text{CFL}$
  $= \text{CFL}$

(Since DCFL is not closed under union, so move upward in Chomsky hierarchy)

- $L_1 \cap L_2 = \text{DCFL} \cap \text{DCFL}$
  $= \text{CFL} \cap \text{CFL}$
  $= \text{CSL} \cap \text{CSL}$
  $= \text{CSL}$

(Since DCFL and CFL are not closed under intersection so move upward in Chomsky hirarchy)

- $L_2 \cap L_3 = \text{DCFL} \cap \text{CFL}$
  $= \text{CFL} \cap \text{CFL}$
  $= \text{CSL} \cap \text{CSL}$
  $= \text{CSL}$

(Since DCFL and CFL are not closed under intersection so move upward in Chomsky hirarchy)

- $L_3 \cap R$ = CFL $\cap$ Reg
  = CFL

(CFL $\cap$ Regular is CFL only according to closure property)

40. (c)

Disk block size = 5000 records
Block size = 10 records or 15 (keys + Pointers)

Sparse index at 1st level. So number of disk block at 1st level is number of block in database.

$$\text{Data base} = \frac{5000}{10} = 500 \text{ blocks}$$

$$1^{st} \text{ level} = \left\lceil \frac{500}{15} \right\rceil = \lceil 33.33 \rceil = 34 \text{ blocks}$$

$$2^{nd} \text{ level} = \left\lceil \frac{34}{15} \right\rceil = \lceil 2.26 \rceil = 3 \text{ blocks}$$

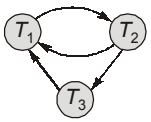
3^{rd} level = 1 block
Total = [500 + 34 + 3 +1] blocks
= 538 blocks

41. (d)

Checking $QS \to P$, $Q^+ = Q$, $S^+ = S$, Hence $QS \to P$ is essential.
Checking $WS \to R$, $WS \to T$
$W^+ \to WVSRT$, Hence it can be decomposed to $W \to R$, $W \to T$
So, the dependencies remained are
$W \to V$, $W \to S$, $T \to S$, $W \to R$, $W \to T$, $QS \to P$
Now, $\{W \to T, T \to S\}$ by transitive rule $W \to S$ can be obtained.
Hence minimal cover is: $W \to V$, $T \to S$, $W \to R$, $W \to T$, $QS \to P$.

42. (d)

Checking for conflict serializable:



Cycle is present
So not conflict serialiazable

Since their is blind write between W_2 (a) to W_3 (a), so it may be view serializable.
Checking for view serializability:

1. Final write: $a = T_1, b = T_3$ (1)
2. Initial read: $a = T_1, T_2\ b = T_3, c = T_1$ (2)
3. Write read: No write read
   $(T_2, T_3) \to T_1$ from (1)
   $T_1 \to T_2, T_3$ from (2)

Both at a time not possible, so not view serializable.

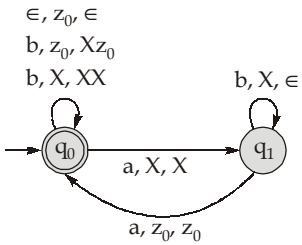
43. (a)

Using Arden's method

$$y = z_0 + y_1 + z_0$$
$$z = z_0 + y_1 + z_0$$
$$L_1 = L_2$$

44. (a)

The PDA for given transition function is:



$$L = \{(b^n ab^n a)^m \mid m, n \geq 0\}$$

For clearer understanding, kindly refer the solution video of this question.

45. (d)

$L_1 = \{a^n b^n \mid n \geq 0\}$ is DCFL and CFL also.

$L_2 = \{b^n c^n \mid n \geq 0\}$ is DCFL and CFL also.

We know that CFL · CFL = CFL

So, $L_1 \cdot L_2 = \{a^n b^n b^m c^m \mid n, m \geq 0\}$ which is CFL and we can see that $L_1 \cdot L_2$ is clearly not equal to $\{a^n b^{2n} c^n \mid n \geq 0\}$.

So II is not true.

So answer is option (d).

46. (a)

Clock cycles	Instruction (operation)
1	SUB
1	ADD
3	MUL

	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}	c_{11}
I_0	IF	ID	OP	MA	WB						
I_1		IF	ID	OP	MA	WB					
I_2			IF	ID	OP	OP	OP	MA	WB		
I_3				IF	ID			OP	MA	WB	
I_4					IF			ID	OP	MA	WB

Total number of clock cycles needed for given program is 11.

47. (c)

(a) Wait (B), wait (A), wait (A), wait (B).
If X_1 is executed in process P and then process is preempted and X_3 is executed there is deadlock condition.

(b) Wait (A), wait (B), wait (B), wait (A)
There also deadlock may occurs.

(c) Wait (A), wait (B), wait (A), wait (B)
This is the correct implementation.

48. (a)

1. If we take $X = 1$, $Y = 1$, then after process -1 or process-3 if both are concurrently running, then both of the processes will block and will stuck in deadlock situation.
2. If we take $X = 2$, $Z = 1$, $Y = 0$ or $X = 1$, $Y = 0$, $Z = 2$ then only one of the output above mentioned will print.
3. An $X = 2$, $Y = 0$, $Z = 2$, if either process-1 or process-3 starts, it will set value to $X = 1$, $Y = 0$, $Z = 1$ and if either process want to interrupt, then it will set value to $X = 0$, $Y = 0$, $Z = 0$ and then output will be printed.

49. (d)

$$\begin{aligned} \text{FIRST } \{B\} &= \{b, \in\} \\ \text{FOLLOW } \{B\} &= (\text{FIRST } (C) - \{\in\}) \cup \text{FOLLOW } (A) \cup \text{FIRST } (b) \\ &= \{c\} \cup \{\$\} \cup \{b\} \\ &= \{b,c, \$\} \end{aligned}$$

50. (c)

$\{t \mid \exists r \in \text{student } (r[\text{ID}] = t[\text{ID}]) \wedge (\forall u \in \text{course } (u[\text{dept\_name}] = \text{“CS”} \Rightarrow \exists s \in \text{takes } (t[\text{ID}] = s[\text{ID}] \wedge s[\text{course\_id}] = u[\text{course\_id}]))\}$ will results all students who have taken all courses offered in the CS department. Since we know that $P \Rightarrow Q \equiv \text{not } P \vee Q$, so option (b) is also true.

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