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GATE 2018
Computer Science
Questions & Solutions

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GENERAL APTITUDE

1. What is the missing number in the following sequence?
   2, 12, 60, 240, 720, 1440, ________, 0
   A. 2880 B. 1440
   C. 720 D. 0

Ans. B

Solutions:
So, 1440 must be answer.

2---- 2*6---- 12*5---60---60*4--------1440*1----1440*0= 0

2. "From where are they bringing their books? _________ bringing _________ books from __________."
   The words that best fill the blanks in the above sentence are
   A. Their, they're there
   B. They're, their, there
   C. There, their, they're
   D. They're, there, there

Ans. B
Solutions:
In this question They're used for pointing group. There is pointing people. There is used for place.

3. What would be the smallest natural number which when divided either by 20 or by 42 or by 76 leaves a remainder of 7 in each case?
   A. 3047 B. 6047
   C. 7987 D. 63847

Ans. C
Solutions:
From the given number is divided by either by 20 or 42 or by 76
K*LCM (20,42,76) + constant difference = 7890 K + 7 is natural number .
So the Ans is 7897

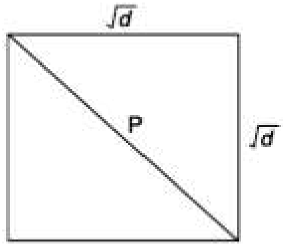
4. "A ___________ investigation can sometimes yield new facts, but typically organized ones are more successful."
   A. meandering B. timely
   C. consistent D. systematic

Ans. A
Solutions: Meandering: mean is wandering aimlessly/indirect. Consistent is acting or done in the same way over time

5. The area of a square is d. What is the area of the circle which has the diagonal of the square as its diameter?
   A. πd B. πd^2
   C. $\frac{1}{4}\pi d^2$ D. $\frac{1}{2}\pi d$

Ans. D

Solutions:



$$\text{Area of square} = d$$
$$\text{Side one side of square} = \sqrt{d}$$
$$\text{Diagonal of square} = \sqrt{d+d} = \sqrt{2d}$$
$$\text{Area of circle} = \pi r^2$$
$$= \pi\left(\frac{\sqrt{2d}}{2}\right)^2$$
$$= \pi\frac{d}{2}$$
$$= \frac{1}{2}\pi d$$

6. In $pqr \neq 0$ and $p^{-x} = \frac{1}{q}, q^{-y} = \frac{1}{r}, r^{-z} = \frac{1}{p}$, what is the value of the product xyz?

A. -1 B. $\frac{1}{pqr}$

C. 1 D. pqr

Ans. C

Solution:

$$p^x = q$$
$$q^y = r$$
$$x \log p = \log q$$
$$y \log q = \log r$$
$$z \log r = \log p$$
$$x = \frac{\log q}{yp}$$
$$y = \frac{yz}{\log q}$$
$$z = \frac{\log p}{yr}$$
$$x \times y \times z = 1$$

7. In appreciation of the social improvements completed in a town, a wealthy philanthropist decided to gift Rs 750 to each male senior citizen in the town and Rs 1000 to each female senior citizen. Altogether, there were 300 senior citizens eligible for this gift. However, only 8/9th of the eligible men and 2/3rd of the eligible women claimed the gift. How much money (in Rupees) did the philanthropist give away in total?

A. 1,50,000 B. 2,00,000

C. 1,75,000 D. 1,51,000

Ans. B

Solutions:

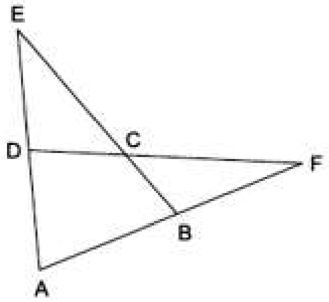
$$\text{Male} + \text{Female} = 300 \qquad \ldots(i)$$

$$\text{Total money} = \frac{8}{9}M \times 750 + \frac{2}{3}F \times 1000$$
$$= \frac{6000}{9}M + \frac{6000}{9}F$$
$$= \frac{6000}{9}(M+F)$$

From equation (i)

$$\text{Total money} = \frac{6000}{9}(300) = 2,00,000$$

8. In the figure below, $\angle DEC + \angle BFC$ is equal to ___________.

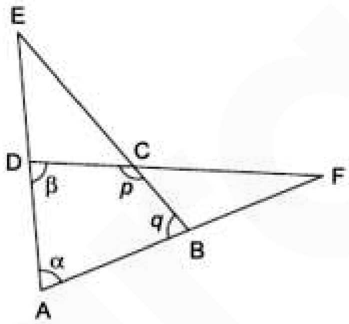


A. $\angle BCD - \angle BAD$ B. $\angle BAD + \angle BCF$

C. $\angle BAD + \angle BCD$ D. $\angle CBA + \angle ADC$

Ans. A

Solutions:



$$\angle E + \angle F = ?$$
$$\alpha + q + E = 180 \qquad \ldots(i)$$
$$\alpha + \beta + F = 180 \qquad \ldots(ii)$$
$$\alpha + \beta + p + q = 360 \qquad \ldots(iii)$$

Equation (i) + (ii) = (iii)

$$\alpha + q + E + \alpha + \beta + F = \alpha + \beta + p + q$$
$$E + F = p - \alpha$$

9. A six sided unbiased die with four green faces and two red faces is rolled seven times. Which of the following combinations is the most likely outcome of the experiment?

A. Three green faces and four red faces.

B. Four green faces and three red faces.

C. Five green faces and two red faces.

D. Six green faces and one red face.

Ans. C

Solution:
Four green, two red face

$$P(G) = \frac{4}{6} = \frac{2}{3}$$
$$q(R) = \frac{1}{3}$$
$$n = 7$$

Option (1),

$$P(G=3) = {}^7C_3 \left(\frac{2}{3}\right)^3 \left(\frac{1}{4}\right)^4$$
$$= \frac{35 \times 2^3}{(3)^7} = \frac{35 \times 2^3}{(3)^7}$$

(2), $P(G=4) = {}^7C_4 \times \left(\frac{2}{3}\right)^4 \times \left(\frac{1}{3}\right)^3$

$$= \frac{35 \times 2^4}{(3)^7} = \frac{35 \times 2^4}{(3)^7}$$

(3), $P(G=5) = {}^7C_5 \times \left(\frac{2}{3}\right)^5 \times \left(\frac{1}{3}\right)^2$

$$= \frac{21 \times 2^5}{(3)^7} = \frac{42 \times 2^4}{(3)^7}$$

(4), $P(G=6) = {}^7C_6 \times \left(\frac{2}{3}\right)^6 \times \left(\frac{1}{3}\right)$

$$= \frac{7 \times 2^6}{(3)^7} = \frac{28 \times 2^4}{(3)^7}$$

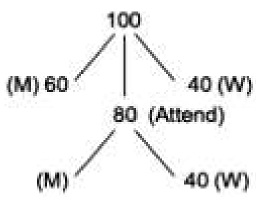
Option 3 is maximum value.
So, five green faces and two red faces.

10. In a party, 60% of the invited guests are male and 40% are female. If 80% of the invited guests attended the party and if all the invited female guests attended, what would be the ratio of males to females among the attendees in the party?

A. 2 : 3 B. 1 : 1
C. 3 : 2 D. 2 : 1

Ans. B

Solutions: Let total number of people are 100.



So, M must be 80 – 40 = 40
Ratio of male of female
40 : 40
1 : 1

COMPUTER SCIENCE

1. Consider a long-lived TCP session with an end-to-end bandwidth of 1 Gbps (= 10^9 bits-per-second). The session starts with a sequence number of 1234. The minimum time (in seconds, rounded to the closest integer) before this sequence number can be used again is __________.

Ans. 34

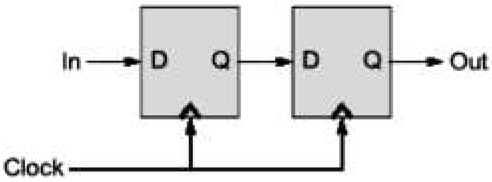
Solutions:

$$1 \text{ sec} = 10^9 \text{ bits}$$

$$\frac{2^{32} \times 8}{10^9} = 2^{32} \text{ bytes}$$

$\Rightarrow$ 34.35 sec

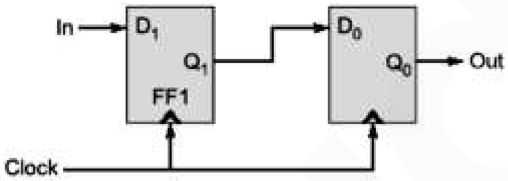
2. Consider the sequential circuit shown in the figure, where both flip-flops used are positive edge-triggered D flip-flops.



The number of states in the state transition diagram of the circuit that have a transition back to the same state on some value of "in" is ___________.

Ans. (2)

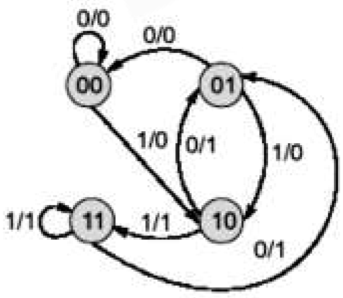
Solutions:



State Table:

P.S.		Input	FF inputs		N.S.		
Q_1	Q_0	x	$D_1 = x$	$D_0 = Q_1$	Q_1	Q_0	Out = Q_0
0	0	0	0	0	0	0	0
0	0	1	1	0	1	0	0
0	1	0	0	0	0	0	0
0	1	1	1	0	1	0	0
1	0	0	0	1	0	1	1
1	0	1	1	1	1	1	1
1	1	0	0	1	0	1	1
1	1	1	1	1	1	1	1

State Transition Diagram:



self-loop states are 00 and 11.
Hence answer is 2.

3. Let $\oplus$ and $\odot$ denote the Exclusive OR and Exclusive NOR operations, respectively. Which one of the following is NOT CORRECT?

A. $\overline{P \oplus Q} = P \odot$

B. $\overline{P} \oplus Q = P \odot$

C. $\overline{P} \oplus \overline{Q} = P \oplus Q$

D. $\left(P \oplus \overline{P}\right) \oplus Q = \left(P \odot\right.$

Ans. D

Solutions:

(D) $\left(P \oplus \overline{P}\right) \oplus Q = \left(P \odot\right.$ false

$\left(P \oplus \overline{P}\right) \oplus Q = 1 \oplus Q = \overline{Q}$

$\left(P \odot \quad \odot \quad \oplus \overline{Q} = Q\right.$

$\therefore \quad \left(P \oplus \overline{P}\right) \oplus Q \neq \left(P \odot \quad \odot\right.$

So, options D is correct ans.

4. A 32-bit wide main memory unit with a capacity of 1 GB is built using $256\ \text{M} \times 4$-bit DRAM chips. The number of rows of memory cells in the DRAM chip is 2^{14}. The time taken to perform one refresh operation is 50 nanoseconds. The refresh period is 2 milliseconds. The percentage (rounded to the closest integer) of the time available for performing the memory read/write operations in the main memory unit is _____________.

Ans. (**59**)

Solutions:

Total number of rows is 2^{14} and time taken to perform one refresh operation is 50 nanoseconds. So, total time taken to perform refresh operation = 2^{14}*50 nanoseconds = 819200 nanoseconds = 0.819200 milliseconds.
refresh period is 2 milliseconds. So, time spent in refresh period in percentage = (0.819200 milliseconds) / (2 milliseconds) = 0.4096 = 40.96%
Hence, time spent in read/write operation = 100% – 40.96% = 59.04% = 59 (in percentage and rounded to the closet integer).
So, answer is **59**.

5. Which one of the following is a closed form expression for the generating function of the sequence $\{a_n\}$, where $a_n = 2n + 3$ for all $n = 0, 1, 2, \ldots..$?

A. $\dfrac{3}{(1-x)^2}$ B. $\dfrac{3x}{(1-x)^2}$

C. $\dfrac{2-x}{(1-x)^2}$ D. $\dfrac{3-x}{(1-x)^2}$

Ans. D

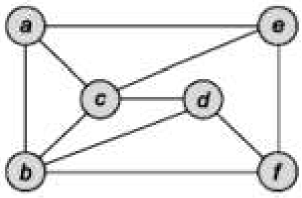
The Given functions is, $a_n = 2n + 3$

generating function for 1 is $\dfrac{1}{1-x}$ and n is $\dfrac{x}{(1-x)^2}$, the generating function for a_n is

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

Which is option (d).

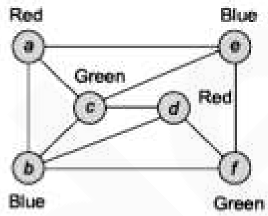
6. The chromatic number of the following graph is ___________.



Ans. (3)

Solutions:

Sub graph is K_3, chromatic number is at least 3. We can try for a chromatic number of 3 by using 3 colors, as follows :



All vertices with only 3 colors, the chromatic number of this graph is 3.

7. In an Entity-Relationship (ER) model, suppose R is a many-to-one relationship from entity set E1 to entity set E2. Assume that E1 and E2 participate totally in R and that the cardinality of E1 is greater than the cardinality of E2.

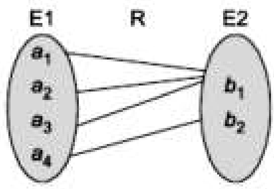
Which one of the following is true about R?

A. Every entity in E1 is associated with exactly one entity in E2.
B. Some entity in E1 is associated with more than one entity in E2.
C. Every entity in E2 is associated with exactly one entity in E1.
D. Every entity in 2 is associated with at most one entity in E1.

Ans. (A)

Solutions:

E1 entries > E2 entities



So Every entity in E1 is associated with exactly one entity in E2. So options A is correct options.

8. Consider the following C program:

```
#include<stdio.h>
Struct ournode {
    Char x, y, z;
};
int main() {
    struct ournode p = {'1', '0', 'a' + 2};
```

```
        struct ournode *p = &q;
        printf("%c, %c", *((char*) q + 1), *((char*) q + 2));
        return 0;
}
```

The output of this program is :

A. 0, c
B. 0, a + 2
C. '0', 'a + 2'
D. '0', 'c'

Ans. A

Solutions:

So 'a' + 2 will be 'c', so Our next node p = {'1', '0', 'c'} and output will be 0, c. So ans is C

9. The value of $\int_0^{\pi/4} x\cos(x^2)\,dx$ correct to three decimal places (assuming that π = 3.14) is __________.

Ans. (0.289)

Solutions: $\int_0^{\pi/4} x\cos(x^2)\,dx$

Let, $t = x^2$

$dt = 2x\ dx$

$\Rightarrow \quad xdx = \frac{dt}{2}$

when $x = 0, t = 0$ and when $x = \frac{\pi}{4}, t = \left(\frac{\pi}{4}\right)^2$

So required integral reduce to

$$\int_0^{(\pi/4)^2} \cos t\,dt = [\sin t]_0^{(\pi/4)^2}$$

$$= \sin\left(\frac{\pi}{4}\right)^2 - \sin(0)$$

$$= \sin\left(\frac{\pi}{4}\right)^2 = 0.28898$$

$$\simeq$$

10. The following are some events that occur after a device controller issues an interrupt while process L is under execution.

(P) The processor pushes the process status of L onto the control stack.
(Q) The processor finishes the execution of the current instruction.
(R) The processor executes the interrupt service routine.
(S) The processor pops the process status of L from the control stack.
(T) The processor loads the new PC value based on the interrupt.

Which one of the following is the correct order in which the events above occur?

A. QPTRS
B. PTRSQ
C. TRPQS
D. QTPRS

Ans. (A)

Solutions:

The Sequence is Processor required to handle the interrupt is :

Q. Processor finishes the execution of the current instruction.
P. Processor pushes the process status of L onto the control stack.
T. Processor loads the new PC value based on the interrupt.
R. Processor executes the interrupt service routine.
S. Processor pops the process status of "L" from the control stack.

11. Consider the following statements regarding the slow start phase of the TCP congestion control algorithm. Note the *cwnd* stands for the TCP congestion window and MSS denotes the Maximum Segment Size.
    i. The *cwnd* increases by 2 MSS on every successful acknowledgement.
    ii. The *cwnd* approximately doubles on every successful acknowledgment.
    iii. The *cwnd* increases by 1 MSS every round trip time.
    iv. The *cwnd* approximately doubles every round trip time.
    Which one of the following is correct?
    A. Only ii and iii are true
    B. Only i and iii are true
    C. Only iv is true
    D. Only i and iv are true

Ans. C

Solutions: *cwnd* is approximately doubles every round-trip time. So option C is correct answer.

12. Two people. P and Q, decide to independently roll two identical dice, each with 6 faces. Numbered 1 to 6. The person with the lower number wins. In case of a tie, they roll the dice repeatedly until there is no tie. Define a trial as a throw of the dice by P and Q. Assume that all 6 numbers on each dice are equi-probable and that all trials are independent. The probability (rounded to 3 decimal places) that one of them wins on the third trial is ___________.

Ans. (0.023)

Solutions:

P(one of them wins is 3rd trial)

= P(Ist trial is Tie) × P(IInd trial is Tie) × P(one of them wins 3rd trial)

P(tie in any trial) = P(P = 1 and Q = 1) + P(P=2 and Q=2) + ... + P(P=6 and Q=6)

$$= \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36} + \frac{1}{36}$$

$$= \frac{6}{36} = \frac{1}{6}$$

$$\text{P(one of them wins)} = 1 - P(\text{Tie})$$

$$= 1 - \frac{1}{6} = \frac{5}{6}$$

So required probability $= \frac{1}{6} \times \frac{1}{6} \times \frac{5}{6} = \frac{5}{216} = 0.023$

(rounded to 3 decimal places)

13. Consider the following two tables and four queries in SQL.

Book (<u>isbn</u>, bname), Stock (<u>isbn</u>, copies)

Query 1 :
```
SELECT B.isbn, S.copies
FROM Book B INNER JOIN
Stock S
ON B.isbn = S.isbn;
```
Query 2 :
```
SELECT B.isbn, S.copies
FROM Book B LEFT OUTER
JOIN Stock S
ON B.isbn = S.isbn;
```
Query 3 :
```
SELECT B.isbn, S.copies
FROM Book B RIGHT JOIN
Stock S
```

```
                ON B.isbn = S.isbn;
Query 4 :       SELECT B.isbn, S.copies
                FROM Book B FULL OUTER
                JOIN Stock S
                ON B.isbn = S.isbn;
```

Which one of the queries above is certain to have an output that is superset of the outputs of the other three queries?

A. Query 1 B. Query 2

C. Query 3 D. Query 4

Ans. D

Solutions: In the given Query 4 is full outer join so that full order join record set superset of records compare to inner join, left outer join && right outer join.

14. Consider a process executing on an operating system that uses demand paging. The average time for a memory access in the system is M units if the corresponding memory page is available in memory and D units if the memory access causes a page fault. It has been experimentally measured that the average time taken for a memory access in the process is X units.

Which one of the following is the correct expression for the page fault. It has been experimentally measured that the average time taken for a memory access in the process is X units.

Which one of the following is the correct expression for the page fault rate experienced by the process?

A. $(D-M)/(X-M)$

B. $(X-M)/(D-M)$

C. $(D-X)/(D-M)$

D. $(X-M)/(D-X)$

Ans. B

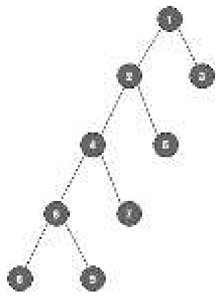
Solutions:

$$\text{EMAT} = P*S+(1-P)*M$$
$$X = P*D+(1-P)*M$$
$$X = P*D+M-P*M$$
$$X-M = P(D-M)$$
$$P = \frac{X-M}{D-M}$$

15. The postorder traversal of a binary tree is 8, 9, 6, 7, 4, 5, 2, 3, 1. The inorder traversal of the same tree is 8, 6, 9, 4, 7, 2, 5, 1, 3. The height of a tree is the length of longest path from the root to any leaf. The height of the binary tree above is ___________.

Ans. (4)

Solutions:



Given, post-order – 8, 9, 6, 7, 4, 5, 2, 3, 1 and in-order – 8, 6, 9, 4, 7, 2, 5, 1, 3 So the height of tree is 4.

16. Let G be a finite group on 84 elements. The size of a largest possible proper subgroup of G is __________.

Ans. (42)

Given $|G| = 84$

Solutions:

By Lagrang's theorem any subgroup size is a divisior of 84.
But a proper subgroup cannot have same size as group.
So largest divisor of 84, other than 84 is 42.
So, largest proper subgroup can have in size of 42.

17. Match the following :

	Field		**Length in bits**
P.	UDP Header's Port Number	I.	48
Q.	Ethernet MAC Address	II.	8
R.	IPv6 Next Header	III.	32
S.	TCP Header's Sequence Number	IV.	16

A. P-III, Q-IV, R-II, S-I
B. P-II, Q-I, R-IV, S-III
C. P-IV, Q-I, R-II, S-III
D. P-IV, Q-I, R-III, S-II

Ans. C

Solutions:

UDP Header's Port Number $\Rightarrow$ 16 bit
Ethernet MAC Address $\Rightarrow$ 48 bit
IPv6 Next Header $\Rightarrow$ 8 bit
TCP Header's Sequence Number $\Rightarrow$ 32 bit

18. Let N be an NFA with n states. Let k be the number of states of a minimal DFA which is equivalent to N. Which one of the following is necessarily true?

A. $k \geq 2^n$ B. $k \geq n$

C. $k \leq n^2$ D. $k \leq 2^n$

Ans. D

Solutions:

n is number of state of given *nfa* (may not be minimal) k is number of states of equivalent min dfa. First we have to convert nfa to dfa using subset construction algorithm and we get an equivalent dfa which will have atmost 2^n states. Then we can convert this dfa to a minimal dfa and get a minimal dfa with k states where $k \leq 2^n$.

19. Consider a system with 3 processes that share 4 instances of the same resource type. Each process can request a maximum of K instances. Resource instances can be requested and released only one at a time. The largest value of K that will always avoid deadlock is ____________.

Ans. (2)

Solutions:

Maximum each process can request for 2 resources so, that there will not be any deadlock, because we, have only 4 resource available.
So, K value is '2'.

20. Consider the following processor design characteristics:
I. Register-to-register arithmetic operations only.
II. Fixed-length instruction format.
III. Hardwired control unit.
Which of the characteristics above are used in the design of a RISC processor?
A. I and II only B. II and III only
C. I and III only D. I, II and III

Ans. D

Solutions:

RISC processor characteristics:
1. It supports mode registers, so ALU operations are performed only on a register data.
2. It support fixed length instructions.
3. It uses hard-wired control unit.

21. The set of all recursively enumerable languages is
A. closed under complementation
B. closed under intersection
C. a subset of the set of all recursive languages
D. an uncountable set

Ans. B

Solutions:

The Set of RE languages is closed under intersection, not closed under complementation, is not a subset of set of REC language and is a countable set.

22. Consider a matrix $A = uv^T$ where $u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}, v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$. Note that v^T denotes the transpose of v.
The largest eigenvalue of A is _________.

Ans. (3)

Solutions:

$$u = \begin{pmatrix} 1 \\ 2 \end{pmatrix}, v = \begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

$$A = uv^T$$

$$= \begin{bmatrix} 1 \\ 2 \end{bmatrix} \begin{bmatrix} 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 1 \\ 2 & 2 \end{bmatrix}$$

$$(1-\lambda)(2-\lambda) - 2 = 0$$

$$\lambda^2 - 3\lambda = 0$$

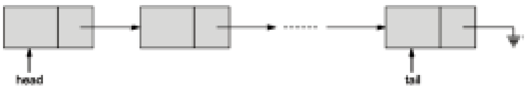
$$\lambda(\lambda - 3) = 0$$

$$\lambda = 0$$

or, $\lambda = 3$

The largest eigen value is 3.

23. A queue is implemented using a non-circular singly linked list. The queue has a head pointer and tail pointer, as shown in the figure. Let n denote of number of nodes in the queue. Let enqueue be implemented by interesting a new node at the head and dequeue be implemented by deletion of a node from the tail.



Which one of the following is the time complexity of the most time-efficient implementation of enqueue and dequeue, respectively, for this data structure?

A. $\theta(1), \theta(1)$

B. $\theta(1), \theta(n)$

C. $\theta(n), \theta(1)$

D. $\theta(n), \theta(n)$

Ans. B

Solutions:

For Enqueue operation, performs in constant amount of time (i.e., Θ(1)) So, the options B is correct.

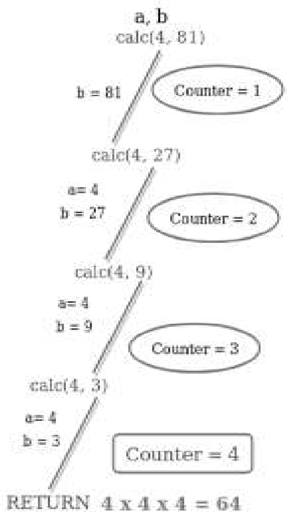
24. Consider the following C program :

```
#include <stdio.h>
int calc (int a, int b) {
    int c;
    counter ++;
    if (b = = 3) return (a*a*a);
    else {
      c = calc (a, b/3);
      return (c*c*c);
    }
}
int main () {
    calc(4, 81);
    printf("%d%d", counter);
}
```

The output of this program is _________.

Ans. (4)

Solutions:



25. Which one of the following statements is FALSE?
   A. Context-free grammar can be used to specify both lexical and syntax rules.
   B. Type checking is done before parsing.
   C. High-level language programs can be translated to different Intermediate Representations.
   D. Arguments to a function can be passed using the program stack.

Ans. (B)

Solutions:

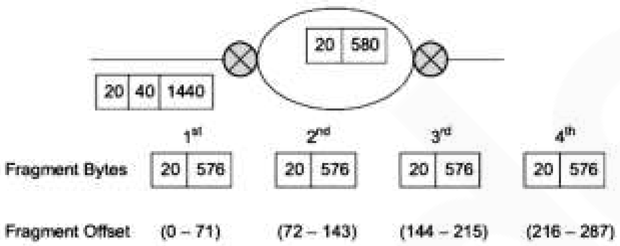
Type checking is done before parsing is clearly false because in compiler type checking is done after parsing phase.

26. Consider an IP packet with a length of 4500 bytes that includes a 20-byte IPv4 header and a 40-byte TCP header. The packet is forwarded to an IPv4 router that supports a Maximum Transmission Unit (MTU) of 600 bytes. Assume that the length of the IP header in all the outgoing fragments of this packet is 20 bytes. Assume that the fragmentation offset value stored in the first fragment offset value stored in the first fragment is 0.

   The fragmentation offset value stored in the third fragment is __________.

Ans. (144)

Solutions:



27. Consider the following four relational schemas. For each schema, all non-trivial functional dependencies are listed. The underlined attributes are the respective primary keys.

Schema I : Registration (<u>rollno</u>, courses)
Field 'courses' is a set-valued attribute containing the set of courses a student has registered for.
rollno → courses

Schema II : Registration (rollno, courseid, email)
Non-trivial functional dependencies:
rollno, courseid → email
email → rollno

Schema III : Registration (<u>rollno, courseid,</u> marks, grade)
Non-trivial functional dependencies:
rollno, courseid → marks, grade
marks → grade

Schema IV : Registration (<u>rollno, courseid,</u> credit)
Non-trivial functional dependencies:
rollno, courseid → credit
courseid → credit

Which one of the relational schemas above is in 3NF but not in BCNF?

A. Schema I   B. Schema II
C. Schema III   D. Schema IV

Ans. B

Solutions:

In Schema II : Registration (rollno, courseid, email)

Non-trivial functional dependencies:

{ rollno, courseid → email

email → rollno }

candidate keys

{rollno, courseid,}

email courseid}

Given relation is in 3NF but not in BCNF.

28. Consider the following problems L(G) denotes the language generated by a grammar G. L(M) denotes the language accepted by a machine M.

I. For an unrestricted grammar G and a string w, where $w \in$ L(G).

II. Given a Turing Machine M, whether L(M) is regular.

III. Given two grammars G_1 and G_2 whether $L(G_1) = L(G_2)$.

IV. Given an NFAN, whether there is a deterministic PDA P such that N and P accept the same language.

Which one of the following statements is correct?

A. Only I and II are undecidable

B. Only III is undecidable

C. Only II and IV are undecidable

D. Only I, II and III are undecidable

Ans. D

Solutions:

Here the match flowing.

I. Membership problem for RE → undecidable

II. Regularity problem for RE → undecidable

III. Equivalence problem for RE → undecidable

IV. Since DPDA P exists for every nfa N and equivalent to it, this problem is trivially decidable.

29. Consider Guwahati (G) and Delhi (D) whose temperatures can be classified as High (H), medium (M) and low (L). Let $P(H_G)$ denote the probability that Guwahati has High temperature. Similarly, $P(M_G)$ and $P(L_G)$ denotes the probability of Guwahati having medium and low temperatures respectively. Similarly, we use $P(H_D), P(M_D)$ and $P(L_D)$ for Delhi.

The following table gives the conditional probabilities for Delhi's temperature given Guwahati's temperature.

	H_D	M_D	L_D
H_G	0.40	0.48	0.12
M_G	0.10	0.65	0.25
L_G	0.01	0.50	0.49

Consider the first row in the table above. The first entry denotes that if Guwahati has high temperature (H_G) then the probability of Delhi also having a high temperature (H_D) is 0.40; i.e., $P(H_D \mid H_G) = 0.40$. Similarly, the next two entries are $P(M_D \mid H_G) = 0.48$ and $P(L_D \mid H_G) = 0.12$. Similarly for the other rows.

If it is known that $P(H_G) = 0.2, P(M_G) = 0.5$ and $P(L_G) = 0.3$, then the probability (correct to two decimal places) that Guwahati has high temperature given that Delhi has high temperature is __________.

Ans. (0.60)

Solutions: The condition probability table given is

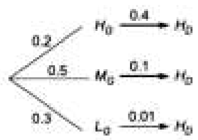
	H_D	M_D	L_D
H_G	0.40	0.48	0.12
M_G	0.10	0.65	0.25
L_G	0.01	0.50	0.49

$P(H_G) = 0.2$

$P(M_G) = 0.5$

$P(L_G) = 0.3$

Drawing the tree diagram for HD we get,



$$P(H_G \mid H_D) \frac{P(H_G \cap H_D)}{P(H_D)}$$

From diagram, $P(H_G \cap H_D) = 0.2 \times 0.4$

$P(H_D) = 0.2 \times 0.4 + 0.5 \times 0.1 + 0.3 \times 0.01$

$= 0.133$

Required probability,

$$P(H_G \mid H_D) = \frac{0.2 \times 0.4}{0.133} = 0.60$$

30. The size of the physical address space of a processor is 2^P bytes. The word length is 2^W bytes. The capacity of cache memory is 2^N bytes, The size of each cache block is 2^M words. For a K-way set-associative cache memory, the length (in number of bits) of the tag field is

A. $P - N - \log_2 K$

B. $P - N + \log_2 K$

C. $P - N - M - W - \log_2 K$

D. $P - N - M - W + \log_2 K$

Ans. B

Solutions:

MM space $= 2^P$ bytes

Pysical Address (PA) size $=$ P bits

CM size $= 2^N$ bytes

Block size $= 2^M$ words

$= 2^M$ words $* 2^W$ bytes/word

$= 2^{(M+W)}$ bytes

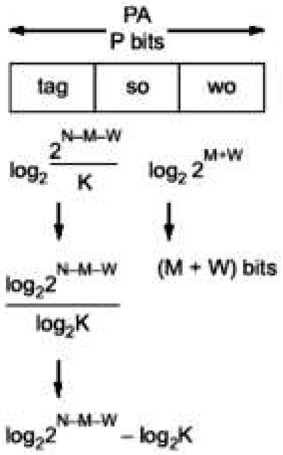
Number of lines $= \dfrac{\text{CM size}}{\text{Block size}} \Rightarrow \dfrac{2^N}{2^{M+W}}$

$\Rightarrow 2^{N-M-W}$

Number of sets $= \dfrac{\text{Number in cm}}{\text{P-way}}$

$= \dfrac{2^{N-M-W}}{K}$

The Address format



$\Rightarrow (N - M - W - \log_2 K)$

$\therefore$ Tag size

$\Rightarrow P - (M + W - \log_2 K + M + W)$

$\Rightarrow P - N + \log_2 K$

31. Consider the following program written in pseudo-code. Assume that x and y are integers:

```
Count (x, y) {
    if (y ! = 1) {
      if (x ! = 1) {
          print("*");
          Count (x/2, y);
      }
      else {
          y = y – 1;
          Count (1024, y);
      }
    }
}
```

The number of times that the print statement is executed by the call Count (1024, 1024) is ___________.

Ans. (10230)

Solutions:

Count(1024, 1024) will be called and value of x will be deducted by x/2. ‘x’ will be printed 10 times. On count=10, value of x will become 1.

For every recursively for every y=1023 and count() is called 10times for each y. So, **1023 x 10 = 10230**

Answer is 10230.

32. Consider the weights and values of items listed below. Note that there is only one unit of each item.

Item Number	Weight in (Kgs)	Value in (Rupees)
1	10	60
2	7	28
3	4	20
4	2	24

The task is to pick a subset of these items such that their total weight is not more than 11 kgs and their total value is maximized. Moreover, no item may be split. The total value of items picked by an optimal algorithm is denoted by V_{opt}. A greedy algorithm sorts the items by their value-to-weight ratios in descending order and packs them greedily, starting from the first item in the ordered list. The total value of items picked by the greedy algorithm is denoted by V_{greedy},

The value of $V_{opt} - V_{greedy}$ is ________.

Ans. (16)

Solutions:

Item No	Weight	Value	Value/Weight
1	10	60	6
2	7	28	4
3	4	20	5
4	2	24	12

After sorting :

Item No	Weight	Value	Value/Weight
4	2	24	12
1	10	60	6
3	4	20	5
2	7	28	4

First, we have to Pick item_1 (Value weight ratio is highest).
After that Second highest is item_1. but cannot be picked because of its weight.
Now item_3 shall be picked. item_2 cannot be included because of its weight.
Therefore, overall profit by $V_{greedy} = 20+24 = 44$
Hence, $\boldsymbol{V_{opt} - V_{greedy} = 60\text{-}44 = 16}$
So, answer is 16.

33. Consider a simple communication system where multiple nodes are connected by a shared broadcast medium (like Ethernet or wireless). The nodes in the system use the following carrier-sense based medium access protocol. A node that receives a packet to transmit will carrier-sense the medium for 5 units of time. If the node does not detect any other transmission in this duration, it starts transmitting its packet in the next time unit. If the node detects another transmission, it waits until this other transmission finishes, and then begins to carrier-sense for 5 time units again. Once they start to transmit, nodes do not perform any collision detection and continue transmission even if a collision occurs. All transmissions last for 20 units of time. Assume that the transmission signal travels at the speed of 10 meters per unit time in the medium. Assume that the system has two nodes P and Q, located at a distance d meters from each other. P starts transmitting a packet at time $t = 0$ after successfully completing its carrier-sense phase. Node Q has a packet to transmit at time $t = 0$ and begins to carrier-sense the medium.

The maximum distance *d* (in meters, rounded to the closest integer) that allows Q to successfully avoid a collision between its proposed transmission and P's ongoing transmission is __________.

Ans. (50)

Solutions:

The Node receives the packet to transmit will carrier-sense the medium for 5 units. Any packet which arrives within 5 unit will be sensed and keep the channel busy.

The Given Signal speed is 10 meter/time. So, 5 unit of time packet can travel **50 meters** in max, that allow Q to avoid the collision.

option (A) is correct.

34. Let G be a simple undirected graph. Let T_D be a depth first search tree of G. Let T_B be a breadth first search tree of G. Consider the following statements:

I. No edge of G is a cross edge with respect to T_D. (A cross edge is G is between two nodes neither of which is an ancestor of the other in T_D).

II. For every edge (u, v) of G, if u is at depth i and v is at depth j in T_B, then $(i - j) = 1$.

Which of the statements above must necessarily be true?

A. I only B. II only

C. Both I and II D. Neither I nor II

Ans. D

Solutions:

For statement (II) take counter example of complete graph of three vertices, i.e., K3 with XYZ, where X is source and Y and Z are in same level. Also, there is an edge between vertices Y and Z, i.e., |i-j| = 0 ≠ 1 in BFS. So, statement became false. Option (A) is correct.

35. Consider the first-order logic sentence

$$\varphi = \exists s \exists t \exists u \forall v \forall w \forall x \forall y \psi(s,t,u,v,w,x,y)$$

where $\psi(s,t,u,v,w,x,y)$ is a quantifier-free-order logic formula using only predicate symbols and possibly equality, but no function symbols. Suppose φ has a model with a universe containing 7 elements.

Which one of the following statements is necessarily true?

A. There exists at least one model of φ with universe of size less than or equal to 3.

B. There exists no model of φ with universe of size less than or equal to 3.

C. There exists no model of φ with universe of size greater than 7.

D. Every model of φ has a universe of size equal to 7.

Ans. B

Solutions:

∀ are always True and ∃ are always False for empty sets.
So there exists at least one model with universe of size 3 (or less than).

Therefore, **option (A) is necessarily TRUE**.

36. Consider the following C program:

```
#include <stdio.h>
void fun 1 (char *s1, char *s2) {
    char *tmp;
    tmp = s1;
    s1 = s2;
    s2 = tmp;
}
```

```
Void fun2 (char **s1, char **s2) {
    char *tmp;
    tmp = s1;
    s1 = s2;
    s2 = tmp;
}
int main () {
    char *str1 = "Hi", *str2 = "Bye";
    fun1 (str1, str2);
    printf("%s %s", str1, str2);
    fun2 (&str1, &str2);
    printf("%s %s", str1, str2);
    return 0;
}
```

The output of the program above is

A. Hi Bye Bye Hi
B. Hi Bye Hi Bye
C. Bye Hi Hi Bye
D. Bye Hi Bye Hi

Ans. A

Solutions:

*fun1(char *s1, char *s2)*
function scope is local, so the value changed So the affect actual parameters. SO the values will be 'Hi Bye'.
*fun2(char **s1, char **s2)*
In this function value is pointer to pointer, so it changes pointer of the actual value. So values will be 'Bye Hi'

37. The number of possible min-heaps containing each value from {1, 2, 3, 4, 5, 6, 7} exactly once is ________.

Ans. (80)

Solutions:

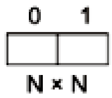
T(N) =(N-1)Ck * T(k) * T(N-k-1), where k = number of nodes on left subtree
T(1) = 1
T(2) = 1
T(3) = 2
T(4) = 3C2 * T(2) * T(1) = 3
T(5) = 4C3 * T(3) * T(1) = 8
T(6) = 5C3 * T(3) * T(2) = 20
T(7) = 5C3 * T(3) * T(3) = 80

38. Let N be the set of natural numbers. Consider the following sets:
P. Set of rational numbers (positive and negative).
Q. Set of functions from {0, 1} to N.
R. Set of functions from N to {0, 1}.
S. Set of finite subsets of N.
Which of the sets above are countable?
A. Q and S only
B. P and S only
C. P and R only
D. P, Q and S only

Ans. D

Solutions: P : Set of rational number → countable

Q : Set of functions from {0, 1} to N → N

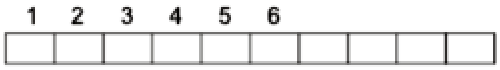


0 can be assigned in N ways

1 can be assigned in N ways

There are $N \times N$ functions, cross product of countable set in countable.

R : Set of functions from N to {0, 1}



Each of thus boxes can be assigned to 0 or 1 so each such function is a binary number with infinite number of bits.

39. Consider the unsigned 8-bit fixed point binary number representation below :

$$b_7\, b_6\, b_5\, b_4\, b_3\, .\, b_2\, b_1\, b_0$$

Where the position of the binary point is between b_3 and b_2. Assume b_7 is the most significant bit. Some of the decimal numbers listed below cannot be represented exactly in the above representation:

i. 31.500 ii. 0.875

iii. 12.100 iv. 3.001

Which one of the following statements is true?

A. None of (i), (ii), (iii), (iv) can be exactly represented.

B. Only (ii) cannot be exactly represented.

C. Only (iii) and (iv) cannot be exactly represented.

D. Only (i) and (ii) cannot be exactly represented.

Ans. C

Solutions:

Binary code: $(b_7\, b_6\, b_5\, b_4\, b_3\, .\, b_2\, b_1\, b_0)_2$

$(31.5)_{10} = (11111.1)_2$

$(0.875)_{10} = (0.111)_2$

$(12.100)_{10} = (01100.000110.....)_2$

$\downarrow$

Only 3 bits of fraction space available.

So can't be stored.

$(3.001)_{10} = (00011.000000..........)_2$

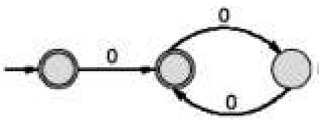
It is also not accurate storage.

40. Given a language L, define L^i as follows:

$L^0 = \{\epsilon\}$

$L^i = L^{i-1}.\, L$ for all $i > 0$

The order of a language L is defined as the smallest k such that $L^k = L^{k+1}$. Consider the language L_1 (over alphabet 0) accepted by the following automaton.



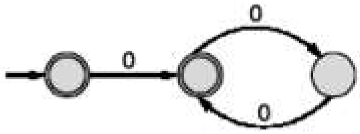
The order of L_1 is ____________.

Ans. (2)

Solutions:

We need to find smallest value of k which satisfies

$$L_1^k = L_1^{k+1}$$



$$L_1 = \in + (00)^*$$

Try $k = 0$; $\quad L_1^0 = L_1^1$

$\Rightarrow \quad \in = L_1$ Which is false.

So order is not 0.

Try $k = 1$: $\quad L_1^1 = L_1^2$

$\Rightarrow \quad L_1^2 = L_1$

Now, $\quad L_1^2 = (\in + 0(00)*)(\in + 0(00)*)$

$$= \in + 0(00)* + 00(00)^* = 0^*$$

Clearly $\quad L_1^2 \neq L_1$

So order is not 1.

Try $k = 2$: $\quad L_1^2 = L_1^3$

Now, $\quad L_1^3 = L_1^2 . L_1$

$$= 0*\left(\in + 0(00)^*\right) = 0^*$$

Clearly $\quad L_1^3 = L_1^2 = 0^*$

(So, order of L_1 is 2)

41. A lexical analyzer uses the following patterns to recognize three tokens T_1, T_2 and T_3 over the alphabet {a, b, c}.

$T_1 : a?(b \mid c)^* a$

$T_2 : b?(a \mid c)^* b$

$T_3 : c?(b \mid a)^* c$

Note that 'x?' means 0 or 1 occurrence of the symbol x. Note also that the analyzer outputs the token that matches the longest possible prefix.

If the string bbaacabc is processed by the analyzer, which one of the following is the sequence of tokens it outputs?

A. $T_1T_2T_3$

B. $T_1T_1T_3$

C. $T_2T_1T_3$

D. T_3T_3

Ans. D

Solutions: Ans is T_3T_3 because from first $T_3\boxed{\text{bbaac}}$ is taken from second $T_3\boxed{\text{abc}}$ is taken longest possible prefix.

Hence T_3T_3 token output.

42. Let G be a graph with 100! Vertices, with each vertex labeled by a distinct permutation of the numbers 1, 2, …. 100. There is an edge between vertices u and v if and only if the label of u can be obtained by swapping two adjacent numbers in the label of v. Let y denote the degree of a vertex in G and z denote the number of connected components in G.

Then, $y + 10z =$ __________.

Ans. (109)

Solutions:

The graph has 100! Vertices which each vertex labeled by one of the 100! Permutation.

take a vertex whose labeling is say 1,2,3,4, …..,100.

Now it will be connected to all vertices where exactly 2 of the adjacent numbers all swapped.

The two swapped numbers could be (1, 2), (2, 3), (3, 4) …. etc. upto (99, 100) which makes for 99 edges for each such vertex.

So the graph is a regular graph with each vertex connected to 99 other vertices.

So $y = 99$

The number of connected components = z = 1 since we can go from any vertex to any other vertex by only swapping 2 adjacent number at a time, many times i.e. there is a path from any vertex to any other vertex.

Graph is connected.

So $z = 1$

So $y + 10z = 99 + 10 \times 1 = 109$

43. The instruction pipeline of a RISC processor has the following stages. Instruction Fetch (IF), Instruction Decode (ID), Operand Fetch (OF), Perform Operation (PO) and Writeback (WB). The IF, ID, OF and WB stages take 1 clock cycle each for every instruction. Consider a sequence of 100 instructions. In the PO stage, 40 instructions take 3 clock cycles each, 35 instructions take 2 clock cycles each, and the remaining 25 instructions take 1 clock cycle each. assume that there are no data hazards and no control hazards. The number of clock cycles required for completion of execution of the sequence of instructions is ____________.

Ans. (219)

Solutions:

	IF	ID	OF	PO	WB
Type (I_1)	1	1	1	3	1
Type (I_2)	1	1	1	2	1
Type (I_3)	1	1	1	1	1

$I_1 : 1 + 1 + 1 + 3 + 1 = 7$

$\left.\begin{matrix} I_2 : \\ I_3 : \end{matrix}\right\}$ usually takes cycles each due to overlapping but I_1 (PO) takes 2 cycles to add "1" cycle extra (2 + 1)

$\Rightarrow \quad 7 + 8 + 1 = 10$

	1	2	3	4	5	6	7	8	9	10
I_1	IF	ID	OF	PO	PO	PO	WB			
I_2		IF	ID	OF	OF	OF	PO	PO	WB	
I_3			IF	ID	ID	ID	OF	OF	PO	PO

	IF	ID	OF	PO	WB
I_1	1	1	1	3	1
I_2	1	1	1	3	1
I_3	1	1	1	2	1
I_4	1	1	1	2	1
I_5	1	1	1	1	1
I_6	1	1	1	1	1

If Type 1 – 2 instruction
Type 2 – 2 instruction
Type 3 – 2 instruction
$I_1 : 1 + 1 + 1 + 3 + 1 = 7$
$I_2 : 1 + 2$ extra cycle $= 3$
$I_3 : 1 + 1$ extra cycle $= 2$
$I_4 : 1 + 1$ extra cycle $= 2$
$I_5 : 1$ extra cycle $= 1$
$I_6 : 1$ extra cycle $= 1$
$= 16$

In this way, if we compute 100 instruction number of cycles required is
If ID OF PO WB
$\Rightarrow 1 + 1 + 1 + \left[(40 \times 3) + (35 \times 2) + (25 \times 1)\right] + 1$
$\Rightarrow$ 219

44. Consider the following solution to the producer-consumer synchronization problem. The shared buffer size is N. Three semaphores empty, full and mutex are defined with respective initial values of 0, N and 1. Semaphore empty denotes the number of available slots in the buffer, for the consumer to read from. Semaphore full denotes the number of available slots in the buffer, for the producer to write to. The placeholder variables, denoted by P, Q, R and S, in the code below can be assigned either empty or full. The valid semaphore operations are: wait ( ) and signal ( ).

Producer:	Consumer

do {
wait (P);
wait (mutex);
//Add item to buffer
signal (mutex);
signal (Q);
} while (1);
	do {
	wait (R);
	wait (mutex);
	//Consume item from buffer
	signal (mutex);
	signal (S);
	} while (1);

Which one of the following assignment to P, Q, R and S will yield the correct solution?
A. P : full, Q: full, R: empty, S; empty
B. P: empty, Q: empty, R: full, S: full
C. P: full, Q: empty, R: empty, S: full
D. P: empty, Q: full, R: full, S: empty

Ans. C

Solutions:

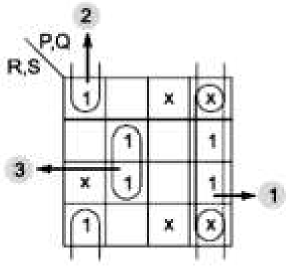
Full = N, empty = 0, mutex = 1
Initially buffer will be empty, so consumer should not start first, so option b, D are eliminated.
With option A consumer will never consume the item, so it is wrong.
Option 'c' is correct answer which proper functionality of produce and consumer.

45. Consider the minterm list form of a Boolean function F given below:
$F(P, Q, R, S) = \Sigma m(0, 2, 5, 7, 9, 11) +$
$d(3, 8, 10, 12, 14)$
Here, m denotes a minterm and d denotes a don't care term. The number of essential prime implicants of the function F is ___________.

Ans. (3)

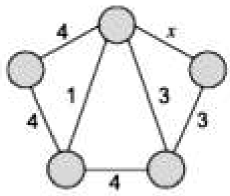
Solutions:

$F(P, Q, R, S) = \Sigma m(0, 2, 5, 7, 9, 11) +$
$d(3, 8, 10, 12, 14)$



Number of EPI = 3

46. Consider the following undirected graph G:



Choose a value of x that will maximize the number of minimum weight spanning trees (MWSTs) of G. The number of MWSTs of G for this value of x is ____________.

Ans. (4)

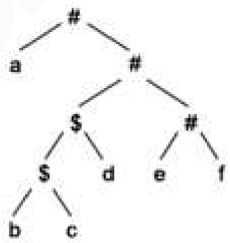
Solutions:

- ✓ Edges with weights 1 and 3 will be selected first,
- ✓ Now bottom edge with weight 4 will not be selected as will cause cycle on MST,
- ✓ both corner vertices have two-two choices to select the vertices, so these corner edges with weights 4 and 5 will resultant 2*2 = 4 MSTs.

So, total number of MSTs are 2*2 = 4, which is answer.

Option (A) is correct.

47. Consider the following parse tree for the expression a#bcd#e#f, involving two binary operators $ and #.



Which one of the following is correct for the given parse tree?

A. $ has higher precedence and is left associative; # is right associative
B. # has higher precedence and is left associative; $ is right associative
C. $ has higher precedence and is left associative; # is left associative
D. # has higher precedence and is right associative; $ is left associative

Ans. A

Solutions:

here $ is higher precedence than # $ is left associative because in the sub expression b $ c $ d, b $ c will be evaluated first as per given tree.

As per the given tree structure right # if higher precedence than left #.

Hence it is right associative.

48. Assume that multiplying a matrix G_1 of dimension $p \times q$ with another matrix G_2 of dimension $q \times r$ requires scalar multiplications. Computing the product of n matrices $G_1G_2G_3....G_n$ can be done by parenthesizing in different ways. Define $G_i\,G_{i+1}$ as an explicitly computed pair for a given parathesization if they are directly multiplied. For example, in the matrix multiplication chain $G_1G_2G_3G_4G_5G_6$ using parenthesization $(G_1(G_2G_3))(G_4(G_5G_6)).G_2G_3$ and G_5G_6 are the only explicitly computed pairs.

Consider a matrix multiplication chain $F_1F_2F_3F_4F_5$, where matrices F_1, F_2, F_3, F_4 and F_5 are of dimensions $2 \times 25, 25 \times 3, 3 \times 16,$ 16×1 and $1 \times 1000,$ respectively. In the parenthesization of $F_1F_2F_3F_4F_5$ that minimizes the total number of scalar multiplications, the explicitly computed pairs is/are

A. F_1F_2 and F_3F_4 only

B. F_2F_3 only

C. F_3F_4 only

D. F_1F_2 and F_4F_5 only

Ans. C

Solutions:

Total number of scalar multiplications are 48 + 75 + 50 + 2000 = 2173 and optimal parenthesis is ((F1(F2(F3 F4))) F5). As concluded, F3, F4 are explicitly computed pairs.

49. In a system, there are three types of resources: E, F and G. Four processes P_0, P_1, P_2 and P_3 execute concurrently. At the outset, the processes have declared their maximum resource requirements using a matrix named Max as given below. For example Max$[P_2, \text{F}]$ is the maximum number of instances of F that P_2 would require. The number of instances of the resources allocated to the various processes at any given state is given by a matrix named allocation.

Consider a state of the system with the Allocation matrix as shown below and in which 3 instances of E and 3 instances of F are the only resources available.

Allocation			
	E	F	G
P_0	1	0	1
P_1	1	1	2
P_2	1	0	3
P_3	2	0	0

Max			
	E	F	G
P_0	4	3	1
P_1	2	1	4
P_2	1	3	3
P_3	5	4	1

From the perspective of deadlock avoidance, which one of the following is true?

A. The system is in safe state.

B. The system is not in safe state, but would be safe if one more instance of E were available.

C. The system is not in safe state, but would be safe if one more instance of F were available.

D. The system is not in safe state, but would be safe if one more instance of G were available.

Ans. A

Solutions:

	Max need			Current allocation			Current available			Remaining need		
	E	F	G	E	F	G	E(3)	F(3)	G(0)	E	F	G
P_0	4	3	1	1	0	1	4	3	1	3	3	0
P_1	2	1	4	1	1	2	5	3	4	1	0	2
P_2	1	3	3	1	0	3	6	4	6	0	3	0
P_3	5	4	1	2	0	0	8	4	6	3	4	1

Safe sequence : P_0, P_2, P_1, P_3

Safe state

50. Consider the relations $r(A,B)$ and $s(B,C)$, where $s.B$ is a primary key and $r.B$ is a foreign key referencing $s.B$. Consider the query

$$Q : r \bowtie \qquad _{5}(s))$$

Let LOJ denote the natural left outer-join operation. Assume that r and s contain no null values. Which one of the following queries is NOT equivalent to Q?

A. $\sigma_{B<5}(r \bowtie$

B. $\sigma_{B<5}(r \text{ LOJ } s)$

C. $r \text{ LOJ}(\sigma_{B<5}(s))$

D. $\sigma_{B<5}(r)\text{LOJ } s$

Ans. C

Solutions:

R

A	B
a_1	2
a_2	4
a_3	4
a_4	6
a_5	6

S

B	C
2	c_1
4	c_2
4	c_2
8	c_2

Foreign key Primary key

Given query : $r \bowtie \qquad _{5}(s))$

A	B	C
a_1	2	c_1
a_2	4	c_1
a_3	4	c_1

$A : \sigma_{B,5}(r \bowtie$

A	B	C
a_1	2	c_1
a_2	4	c_1
a_3	4	c_1

$B : \sigma_{B,5}(r \bowtie$

A	B	C
a_1	2	c_1
a_2	4	c_1
a_3	4	c_1

$C : r \bowtie \qquad _{5}(s))$

A	B	C
a_1	2	c_1
a_2	4	c_1
a_3	4	c_1
a_4	6	Null
a_5	6	Null

$D : \sigma_{B<5}(r) \bowtie$

A	B	C
a_1	2	c_1
a_2	4	c_1
a_3	4	c_1

Option "c" query result not equal to given query.

51. Consider the following C code. Assume that unsigned long int type length is 64 bits.

```
Unsigned long int fun (unsigned long int n)
{
unsigned long int i, j = 0, sum = 0;
for (I = n; I > 1; I = i/2) j++;
for (; j > 1; j = j/2) sum++;
return (sum);
}
```

The value returned when we call fun with the input 2^{40} is

A. 4 B. 5

C. 6 D. 40

Ans. B

Solutions:

```
// n takes 2^40
unsigned long int fun(unsigned long int n) {
    // initialized sum = 0
    unsigned long int i, j, sum = 0;

    //First it takes i = n = 2^40,
    //then it divides i by 2 and incremented once j
    //each time, that's will make makes j = 40,
    for( i=n; i>1; i=i/2) j++;

    //Now the value of j = 40,
    //it divides j by 2 and incremented once sum
    //each time, that's will make makes sum = 5,
    for( ; j>1; j=j/2) sum++;

    //returns sum = 5
    return sum;
}
```

So, answer is 5.

52. Consider the following languages:

I. $\{a^m b^n c^p d^q \mid m+p=n+q,\text{ where } m,n,p,q \geq 0\}$

II. $\{a^m b^n c^p d^q \mid m=n \text{ and } p=q,\text{ where } m,n,p,q \geq 0\}$

III. $\{a^m b^n c^p d^q \mid m=n=p \text{ and } p \neq q,\text{ where } m,n,p,q \geq 0\}$

IV. $\{a^m b^n c^p d^q \mid mn=p+q,\text{ where } m,n,p,q \geq 0\}$

Which of the language above are context-free?

A. I and IV only

B. I and II only

C. II and III only

D. II and IV only

Ans. B

Solutions:

I. $\{a^m b^n c^p d^q \mid m+p=n+q\}$ is clearly CFL since, we can rearrange the equation as $m-n+p-q=0$ which can be done by push, pop, and pop and check if stack is empty at end.

II. $\{a^m b^n c^p d^q \mid m=n \text{ and } p=q\}$ is clearly CFL since, one comparison at a time can be done by pda.

III. $\{a^m b^n c^p d^q \mid m=n=p \text{ and } p \neq q\}$ is not CFL since $m=n=p$ is a double comparison which cannot be done by PDA.

IV. $\{a^m b^n c^p d^q \mid mn=p+q\}$ is not a CFL, since mn involves multiplying number of a's and number b's which cannot be done by a PDA.

So, only I and II are CFL's.

53. A processor has 16 integer registers (R0, R1, …… R15) and 64 floating point registers (F0, F1, ……, F63). It uses a 2-byte instruction format. There are four categories of instructions. Type-1, Type-2, Type-3 and Type-4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand (1R + 1F). Type-4 category consists of N instructions, each with a floating point register operand (1F).
The maximum value of N is __________.

Ans. (32)

Solutions:

Instruction size = 16 bit

Type I instruction design :

16 bit

opcode	IR	IR	IR
4 bit	4 bit	4 bit	4 bit

$$\text{Number of operations} = 2^4$$
$$= 16$$
$$\downarrow$$
$$\text{Face opcodes} = 16-4$$
$$= 12$$

Type II instruction design:

16 bit

opcode	FR	FR
4 bit	6 bit	6 bit

Face opcodes after type 1 instruction = 12

Face opcodes after type 2 instruction

$$= 12-8$$
$$= 4$$

Type III instruction design:

16 bit

opcode	IR	FR
6 bit	4 bit	4 bit

$$\text{Expand opcode size} = 6 \text{ bit}$$
$$\downarrow$$
$$\text{Number of opcodes} = 4 \times 2^2$$
$$= 16$$

$\therefore$ Number of free opcodes after type 3 instruction $= 16 - 14$
$= 2$

Type IV instruction design :

16 bit

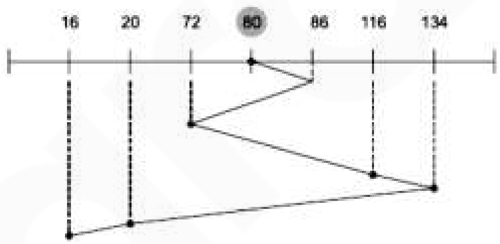
opcode	FR
10 bit	6 bit

$$\text{Expand opcode size} = 10 \text{ bit}$$
$$\downarrow$$
$$\text{Number of opcodes} = 2 \times 2^4$$
$$= 2^5$$
$$= 32$$

54. Consider a storage disk with 4 platters (numbered as 0, 1, 2 and 3), 200 cylinders (numbered as 0, 1, …., 199) and 256 sectors per track (numbered as 0,1, ….., 255). The following 6 disk requests of the form [sector number, cylinder number, platter number] are received by the disk controller at the same time:
[120, 72, 2], [180, 134, 1], [60, 20, 0], [60, 20, 0], [212, 86, 3], [56, 116, 2], [118, 16, 1]
Currently the head is positioned at sector number 100 of cylinder 80 and is moving towards higher cylinder numbers. The average power dissipation in moving the head over 100 cylinders is 20 milliwatts and for reversing the direction of the head movement once is 15 milliwatts. Power dissipation associated with rotational latency and switching of head between different platters is negligible.
The total power consumption in milliwatts to satisfy all of the above disk requests using the Shortest Seek Time First disk scheduling algorithm is ____________.

Ans. (85)

Solutions:



$$(86-80)+(86-72)+(134-72)+$$
$$(134-16)+62+118+14=200$$

$100 \rightarrow 20$

$200 \rightarrow ?$

$$\frac{200}{100} \times 20 = 40$$

3 direction changes $3 \times 15 = 45$

$$40 + 45 = 85$$

55. Consider a matrix P whose only eigenvectors are the multiples of $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$.

Consider the following statements :

I. P does not have an inverse.

II. P has a repeated eigenvalue.

III. P cannot be diagonalized.

Which one of the following options is correct?

A. Only I and II are necessarily true

B. Only II is necessarily true

C. Only I and II are necessarily true

D. Only II and III are necessarily true

Ans. D

Solutions:

Only Eigen vector is $\begin{bmatrix} 1 \\ 4 \end{bmatrix}$ multiples means that eigen value is repeated since if eigen values were distinct we will get one more independent eigen vector. So, II P has repeated eigen value is true. I need not be true since $\begin{bmatrix} 2 & 0 \\ 0 & 2 \end{bmatrix}$ has repeated eigen values and yet it is invertible. III is true since if matrix has repeated eigen values then it cannot be diagonalizable.

***