DETAILED SOLUTIONS

GATE 2022

COMPUTER SCIENCE & INFORMATION TECHNOLOGY

Forenoon Session - 05.02.2022

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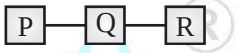
Technical Section

Computer Networks

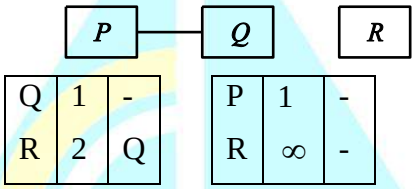
Question 1

Consider network with three routers P, Q, and R. All links have cost of unit, the routers exchange distance vector routing information & converge on routing tables. After some time link Q-R fails, assume P & Q send out routing update at random time, each at same average rate. The probability of routing loop form (Rounded off to one decimal place) between P & Q leading to count to infinity problem is_____.



Ans. **0.5**

Sol.



The link between the Q - R is broken, so the probability after the convergence depends on the sharing of information between nodes P and Q, if the node Q share the information first then there will be no looping, if node P shares the information then there will be chance of looping so the probability will be 0.5

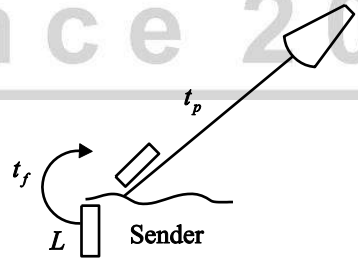
So, $P = \frac{1}{2} = 0.5$

Question 2

Consider a 100 Mbps link between an earth station (sender) and a satellite (receiver) at an altitude of 2100 km. The signal propagates at a speed of 3×10^8 m/s. The time taken (in milliseconds runoff to 2 decimal places) for the receiver to completely receive a packet of 1000 bytes transmitted by the sender is _____.

Ans. **7.08**

Sol.



$$t_p = \frac{d}{s} = \frac{2100\,\text{km}}{3\times10^8\,\text{m/s}} = \frac{2100\times10^3\,\text{m}}{3\times10^8\,\text{m/s}}$$

$$= 7\times10^{-3}\,\text{sec} = 7\text{ms}$$

$$t_t = \frac{L}{R} = \frac{1000\,\text{bytes}}{100\ \text{Mbps}} = \frac{1000\times 8\ \text{bits}}{100\times 10^6\,\text{bits/sec}}$$

$$= \frac{8}{100}\times 10^{-3}\,\text{sec} = 0.08\,\text{ms}$$

$$T = t_t + t_p = 0.08 + 7ms = 7.08\ \text{ms}$$

Question 3

What is the minimum number of bits required for sequence number field in a TCP connection to send maximum segment life time of 60 sec if the bandwidth of connection is 1 Gbps, without wrap around time.

Ans. **33**

Sol.

B = 1 Gbps

$$T = \frac{2^n\,bytes}{B},\ n = \text{Sequence Number bits}$$

$$\Rightarrow \quad 60\,\text{sec} = \frac{2^n\times 8\,bits}{10^9\,bits/\text{sec}}$$

$$\Rightarrow \quad 60\times 10^9 = 2^{n+3}$$

$$\Rightarrow \quad \log_2(60\times 10^9) = n+3$$

$$\Rightarrow \quad \log 60 + 9\times\log_2 10 = n+3$$

$$\Rightarrow \quad 5.9 + 29.87 = n+3$$

$$\Rightarrow \quad 35.79 = n+3$$

$$\Rightarrow \quad n+3 = 36$$

$$\Rightarrow \quad n = 33$$

Question 4

In given table

Subnet – 1D	Mask	Interface
12.20.168.0	255.255.254.0	I_0
12.20.166.0	255.255.254.0	I_1
12.20.164.0	255.255.255.252	R_1
12.20.170.0	255.255.254.0	R_2
(default)		R_3

The route aggregation is applied over above table what will be the subnet – ID/mask in aggregated router?

(A) 12.20.164.0/20 (B) 12.20.164.0/21

(C) 12.20.168.0/22 (D) 12.20.164.0/22

Ans. **12.20.164.0/20**

Sol.

(A) 12.20.1010 0100.00000000, here the network address is 12.20.1010 0100.00000000 and this network covers all the required IP addresses and hence the required answer.

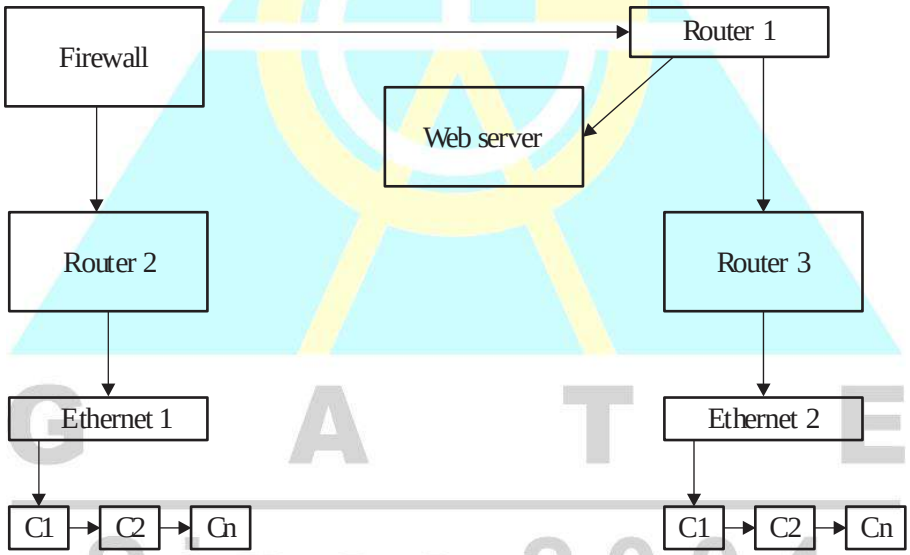
(B) 12.20.10100 100.00000000, here the network address is 12.20.10100 100.00000000, but this network does not have IP address 12.20.170.0, hence this cannot be the answer.

(C) 12.20.101010 00.00000000, here in this network address we do not have IP address 12.20.164.0, hence this cannot be the answer.

(D) 12.20.101001 00.00000000, here in this network we do not have IP address 12.20.170.0, hence this cannot be the answer.

So, 12.20.164.0/20 will be the network – ID of aggregated route.

Q.5 Consider an enterprise network with two Ethernet segments, a web server and a firewall, connected via three routers shown below:-



What is the number of subnets in the enterprise network?

(A) 8 (B) 6

(C) 3 (D) 12

Ans. **C**

Sol. This is just like non equal sub netting where router 2 has the half of the addresses, Router 1 has other half, which is further divided into two subnets which is Web server and router 3, So total of 3 subnets possible.

Q.6 Consider a resolution of domain name www.gate.org.in by a DNS resolver. Assume that no records are called anywhere across the DNS servers and the iterative query resolution mechanism is used in the

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resolution. The number of DNS query response pairs involved in completely resolving the domain name is ____. **[2 Marks, NAT]**

Ans. 3

Sol. In the iterative query the DNS resolver go to the these three servers which is root server, TLD DNS server, authoritative server. So there will be three pairs of request and response here.

Compiler Design

Question 7

Which of the following statements is TRUE?

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

(B) LR (1) parsing is sufficient for DCFL.

(C) The LALR (1) parser for a grammar G cannot have R/R conflict if the LR (1) parser for G does not have R/R conflict

(D) Data flow analysis is necessary for run time memory management.

Ans. **B,C,D**

Sol.

From given statements

Statements B, C, and D are true.

Question 8

Consider the following grammar along with translation rules:

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

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

$T + T, \%R \quad (T.val = T_1 val \div R.val)$

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

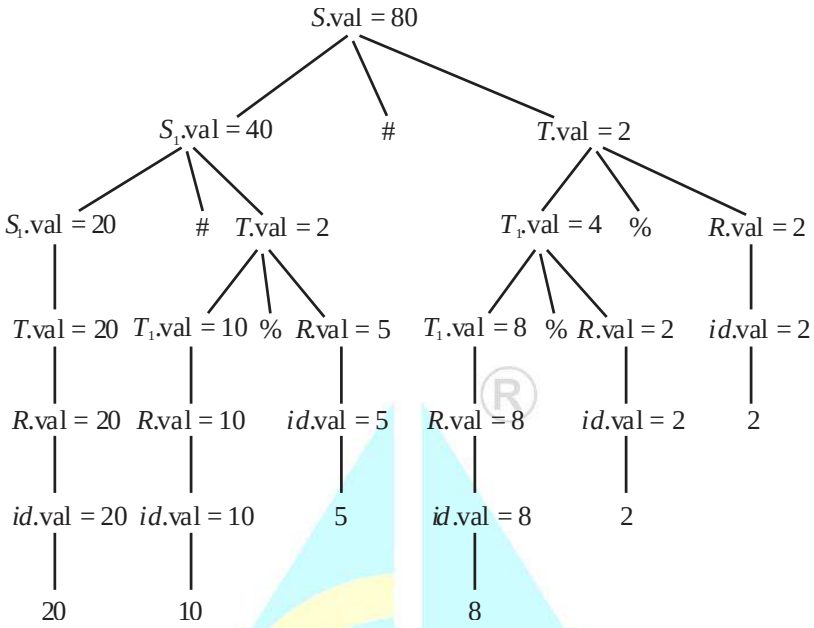
$R \rightarrow id \quad \{R.val = id.val\}$

Using translation rules, the computed value of the S.val for the expression 20#10%5#8%2%2 is _____.

Ans. **80**

Sol.

Annotated parse tree



$\therefore \quad S.\text{val} = 80$

Question 9

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

$S' \to S.$

$S \to S + R \mid R$

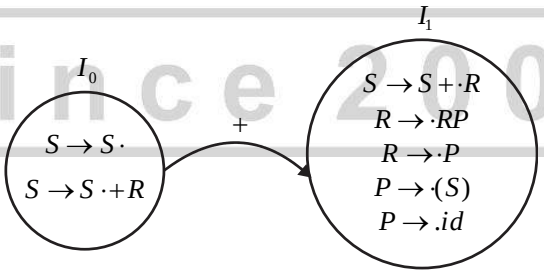
$R \to R * P \mid P$

$P \to (S) \mid id$

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

Ans. 5

Sol.



$\therefore$ 5 item

Computer Organization and Architecture

Question 10

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

Ans. **0.85**

Sol.

$\text{AMAT}_{\text{Old}} = 0.8(10) + 0.2(100) = 8 + 20 = 28.$

Let x be the cache hit rate after optimization.

$\text{AMAT}_{\text{new}} = x(15) + (1-x)100 = 15x + 100 - 100x = 100 - 85x$

$\text{AMAT}_{\text{Old}} \geq \text{AMAT}_{\text{new}}$

$\rightarrow 100 - 85x \leq 28$

$\rightarrow 72 = 85x$

$\rightarrow x = 72/85 = 0.85$

Question 11

Consider 2 kB direct mapped cache, 64 Byte block size 64 kB main memory and 16 bit word size, CPU access words P, Q, R and S respectively 10 times i.e. (P Q R S). Starting address of first byte of P, Q, R and S is respectively.

$$P = A248, Q = CA8A, R = C28A, S = A262$$

Which of the following is/are true (initially cache is empty)

(A) Expect for the first time P is always a hit

(B) S is always a hit

(C) Q is replaced every time R is accessed

(D) S and Q remain in the main memory after complete execution.

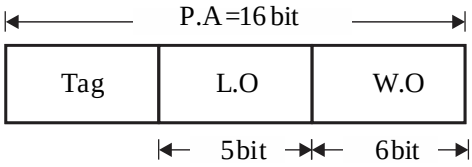
Ans. **A,B,C,D**

Sol. Cache line $\frac{2\text{kB}}{64\text{B}} = 32$

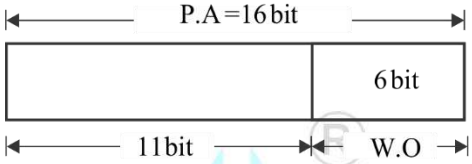
$\therefore$ Line offset $= 5$ bit

Bits in Physical address = $\log_2$(Main memory size = $\log_2$(64 kB) = 16 bit)

Physical address format for direct mapped cache



Physical address format for main memory



Tag in main memory

P	=	A	2	4	8	=	1	0	1	0,	0	0	1	0,	0	1	0	0,	1	0	0	0
Q	=	C	A	8	A	=	1	1	0	0,	1	0	1	0,	1	0	0	0,	1	0	1	0
R	=	C	2	8	A	=	1	1	0	0,	0	0	1	0,	1	0	0	0,	1	0	1	0
S	=	A	2	6	2	=	1	0	1	0,	0	0	1	0,	0	1	1	0,	0	0	1	0
							Tag in cache					L.O					W.O					

- P and S are in same block of memory physical address
- Q and S are different block of main memory but mapped to same cache line.

Question 12

Consider processor x_1 with 5 stage standard RISC pipeline with 2 GHz clock frequency. It requires one clock cycle without any pipeline dependency A program consist of 30% branch instruction, control hazards results in 2 clock cycles. Another pipeline x_2 with same clock cycle frequency uses branch prediction unit with 80 % efficiency. If prediction is correct then no stall is created and if prediction is wrong then no effect in number of stalls. There is no data hazard or structure hazard in the pipeline what is the speed up achieved using x_2 and x_1.

Ans. **1.42**

Sol. Speed Up x_2 over $x_1 = \dfrac{\text{Execution time using } x_1}{\text{Execution time using } x_2}$

$$= \frac{(\text{Avg CPI})_{x_1} \times \text{Cycle time}}{(\text{Avg CPI})_{x_2} \times \text{Cycle time}}$$

$$= \frac{(1+0.3\times 2)\times t_p}{(1+0.3\times(0.8\times 0+0.2\times 2))\times t_p}$$

$$= \frac{1.6}{1.12} = 1.42$$

Question 13

Which facilitates transfer of bulk data from HDD to main memory with highest throughout?

(A) Programmed I/O transfer

(B) Interrupt driven I/O transfer

(C) Polling based I/O transfer

(D) DMA based I/O transfer.

Ans. **D**

Q.14 Let WB and WT be 2 set associative cache organizations that use LRU algorithm for cache block replacement. WB is Write Back cache and WT is Write through cache. Winch of the following statements are false?

1 Mark MSQ

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

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

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

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

Ans. **A and C**

Sol. A. Every write hit in WB leads to a data transfer from cache to main memory. False, for the hit operation no need to fetch the data from the main memory.

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

False.

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

D. Each cache block in WB and WT has a dirty bit

Theory of Computation

Question 15

Which of the following statements is are true?

(A) If L_1 and L_2 are regular, then $L_1 \cap L_2$ must be DCFL.

(B) Every subset of recursively enumerable Language is recursive

(C) If Language L & its complement $\bar{L}$ are both recursively enumerable then L must be recursive

(D) Complement of context free language must be recursive.

Ans. **A,C,D**

Sol.

Option A: True

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If L_1 and L_2 are regular then $L_1 \cap L_2$ is Regular thus also deterministic context free Language.

Option B: False

Since Σ^* is a recursively enumerable Language but there are many languages which are subset of Σ^* which are not Recursive.

Option C: True

If L is recursively enumerable Language, then for all member strings of L, the TM of L will halt within finite time. If $\bar{L}$ is recursively enumerable Language, then for all nonmember strings of L. The TM of $\bar{L}$ will halt within finite time. Thus for both member and nonmember strings of L and $\bar{L}$ we have a TM which halts within finite time. Thus L is a Recursive Language.

Option D: True

Complement of CFL is a CSL in the worst case which is Recursive.

Question 16

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

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

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

Which of the following statements are false?

(A) L_1 is not CFL but L_2 and L_3 are DCFL.

(B) L_2, L_3 and $L_2 \cap L_3$ all are CFL.

(C) Neither L_1 nor L_2 is CFL.

(D) Neither L_1 nor its complement is CFL.

Ans. **B,C,D**

Sol.

$L_1 = \{ww \mid w \in \{a, b\}^*\}$ this language is not CFL but complement of $\bar{L}_1$ is CFL.

$L_2 = \{a^n b^n c^m \mid nm \geq 0\}$ is CFL

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

$L_2 \cap L_3$ is not CFL.

(B), (C) and (D) are false

Question 17

Which of the following is/are undecidable?

(A) Given a TM M, decide is M accepts are strings.

(B) Given a TM, M decide is M takes more than 1073 steps on every string.

(C) Given two turing machines M_1 and M_2 decide of $L(M_1)=L(M_2)$.

(D) Given a TM M, decide is $L(M)$ is regular.

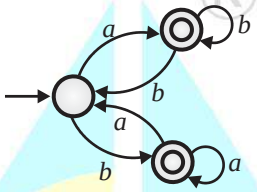
Ans. **A,C,D**

Sol. For a given TM, M decide that m takes more than 1073 steps on every string is decidabe only.

Remaining are undecidable

(A), (C) and (D) are undecidable.

Question 18

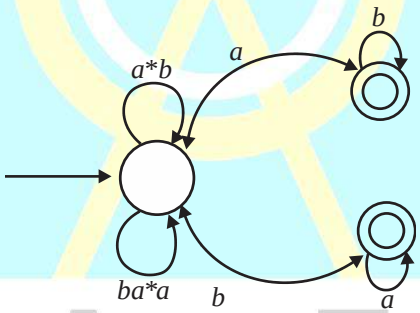


(A) $(ab^*b)^*ab^*+(ba^*a)^*ba^*$ (B) $ab^*bab^*+ba^*aba^*$

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

Ans. **C**

Sol.



$\Rightarrow (ab^*b+ba^*a)(ab^*+ba^*)$

Question 19

Consider language

$$L_1=\left\{a^n\omega a^n \mid \omega\in\{a,b\}^*\right\}$$

$$L_2=\left\{\omega x\omega^R \mid \omega,x\in\{a,b\}^*,|\omega|,|x|>0\right\}$$

Note ω^R is reversal of string ω which is true?

(A) L_1 regular and L_2 is context free language (B) L_1 and L_2 are context free language but not regular

(C) L_1 and L_2 are context free language (D) L_1, L_2 are regular

Ans. **A, C, D**

Sol. $L_1=\{a^n\omega a^n \mid \omega\in(a,b)^*\}$ is regular

$L_2 = \{\omega x \omega^R \,|\, \omega, x \in (a,b)^*, |W|, |x| > 0\}$ is also regular

$\therefore$ Both L_1 and L_2 are regular

Any language which is regular is context free language as well.

Engineering Mathematics

Question 20

The value of the given limit is ____

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

Ans. **– 0.5**

Sol.

$$\lim_{x \to 0+} \frac{\sqrt{x}}{1 - e^{2\sqrt{x}}} \qquad \text{Put } \sqrt{x} = y$$

When

$x \to 0^+$ $\qquad$ $y \to 0$

$$\lim_{y \to 0} \left(\frac{y}{1 - e^{2y}} \right) \Rightarrow \lim_{y \to 0} \frac{1}{0 - e^{+2y}(2)} = \frac{-1}{2}$$

Question 21

Consider simultaneous decomposition LU equation

$x_1 + x_2 - x_3 = 4$

$x_1 + 3x_2 - x_3 = 7$

$2x_1 + x_2 - 5x_3 = 7$

Where L and U are denoted as

$$L = \begin{pmatrix} L_{11} & 0 & 0 \\ L_{21} & L_{22} & 0 \\ L_{31} & L_{32} & L_{33} \end{pmatrix}, U = \begin{pmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U_{23} \\ 0 & 0 & U_{33} \end{pmatrix}$$

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

(A) $L_{32} = 2, U_{33} = 2, x_3 = -1$

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

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

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

Ans. **B**

Sol $LU = A$

$$\begin{bmatrix} 1 & 0 & 0 \\ L_{21} & 1 & 0 \\ L_{31} & L_{32} & 1 \end{bmatrix}\begin{bmatrix} U_{11} & U_{12} & U_{13} \\ 0 & U_{22} & U_{23} \\ 0 & 0 & U_{33} \end{bmatrix} = \begin{bmatrix} 1 & 1 & -2 \\ 1 & 3 & -1 \\ 2 & 1 & -5 \end{bmatrix}$$

$$\begin{bmatrix} U_{11} & U_{12} & U_{13} \\ L_{21}U_{11} & L_{21}U_{12}+U_{22} & L_{21}U_{13}+U_{23} \\ L_{31}U_{11} & L_{31}U_{12}+L_{32}U_{22} & L_{31}U_{13}+L_{32}U_{23}+U_{33} \end{bmatrix} = \begin{bmatrix} 1 & 1 & -2 \\ 1 & 3 & -1 \\ 2 & 1 & -5 \end{bmatrix}$$

$\rightarrow$ Comparing $A_{11,}A_{12}$ and A_{13}

$U_{11} = 1$

$U_{12} = 1$

$U_{13} = -2$

$\rightarrow$ Comparing A_{21},

$L_2.U_{11} = 1$

Putting value of U_{11}

$L_{21} \times 1 = 1$

$L_{21} = 1$

$\rightarrow$ Comparing A_{22}

$L_{21}U_{12} + U_{22} = 3$

Putting value of L_{21} and U_{12}

$1 \times 1 + U_{22} = 3$

$U_{22} = 2$

$\rightarrow$ Comparing A_{23}

$L_{21}U_{13} + U_{23} = -1$

Putting value of L_{21} and U_{13}

$1 \times -2 + U_{23} = -1$

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$U_{23}=1$

→ Comparing A_{31}

$L_{31}U_{11}=2$

Putting value of U_{11}

$L_{31}\times 1=2$

$L_{31}=2$

→ Comparing A_{32}

$L_{31}U_{12}+L_{32}U_{22}=1$

Putting value of L_{31}, U_{12} and U_{22}

$2\times 1+L_{32}\times 2=1$

$L_{32}\times 2=-1$

$$\boxed{L_{32}=\frac{-1}{2}}$$

→ Comparing A_{33}

$L_{31}U_{13}+L_{32}U_{23}+U_{33}=-5$

$2\times -2+\frac{-1}{2}\times 1+U_{33}=-5$

$-4-\frac{1}{2}+U_{33}=-5$

$$\boxed{U_{33}=-\frac{1}{2}}$$

Question 22

Which is /are eigen vector for given matrix true $\begin{pmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{pmatrix}$

(A) $\begin{pmatrix} 0 \\ 1 \\ -3 \\ 0 \end{pmatrix}$

(B) $\begin{pmatrix} -1 \\ 1 \\ 0 \\ 1 \end{pmatrix}$

(C) $\begin{pmatrix} -1 \\ 0 \\ 2 \\ 2 \end{pmatrix}$

(D) $\begin{pmatrix} 1 \\ 0 \\ -1 \\ 0 \end{pmatrix}$

Ans. **A,B,C**

Sol.

Option (A) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} -1 \\ 0 \\ 2 \\ 2 \end{bmatrix} = \begin{bmatrix} -3 \\ 0 \\ 6 \\ 6 \end{bmatrix} = 3 \begin{bmatrix} -1 \\ 0 \\ 2 \\ 2 \end{bmatrix}$$

Option (B) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ -3 \\ 0 \end{bmatrix} = \begin{bmatrix} 0 \\ 3 \\ -9 \\ 0 \end{bmatrix} = 3 \begin{bmatrix} 0 \\ 1 \\ -3 \\ 0 \end{bmatrix}$$

Option (C) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix} = 1 \begin{bmatrix} -1 \\ 1 \\ 0 \\ 1 \end{bmatrix}$$

Option (D) :

$$\begin{bmatrix} -9 & -6 & -2 & -4 \\ -8 & -6 & -3 & -1 \\ 20 & 15 & 8 & 5 \\ 32 & 21 & 7 & 12 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ -1 \\ 0 \end{bmatrix} = \begin{bmatrix} -7 \\ -5 \\ 12 \\ 25 \end{bmatrix}$$

Question 23

Consider the following two statements with respect to the matrices.

$A_{m\times n}, B_{n\times m}, C_{n\times n}$ and $D_{n\times n}$.

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

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

Where $tr()$ represents the trace of a matrix which one of the following holds?

(A) Both statement 1 and 2 are correct.

(B) Statement 1 is true and statement 2 is false

(C) Statement 1 is false and statement 2 is true

(D) Both Statement 1 and 2 are wrong.

Ans. **A**

Sol.

The eigenvalues (counting multiplicity) of AB are the same as those of BA

If A is an m by n matrix and B is an n by m matrix with $n \geq m$ then the characteristic polynomial p_{BA} of BA is related to the characteristic polynomial p_{AB} of AB by

$$p_{BA}(t) = t^{n-m} p_{AB}(t)$$

Since Eigenvalues are the same thus the sum of Eigen Values (i.e. the Trace) is also the same.

Discrete Mathematics

Question 24

Consider a simple undirected graph of 10 vertices if the graph is disconnected then the maximum number of edges it can have is_____.

Ans. **36**

Sol.

Suppose we have 1 vertex on one side and other n-1 vertices on another side. To make it connected maximum possible edges (if consider it as complete graph) is

C_2^{n-1} which is $\frac{(n-1)(n-2)}{2}$

Thus to make it a disconnected graph we have 1 separate vertex on another side which is not connected. Thus the maximum possible edges is

$$C_2^{n-1} = {}^9C_2 = 9*8/2 = 36$$

Question 25

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

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

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

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

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

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

Ans. **B**

Sol.

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

$$G(x) = \sum_{r=0}^{\infty} a_r x^r$$

$$G(x) = \sum_{r=0\,(\text{even})}^{\infty} a_r x^r + \sum_{r=1(\text{odd})}^{\infty} a_r x^r$$

$$G(x) = \sum_{r=0\ \text{even}}^{\infty} x^r + \sum_{r=1\ \text{odd}}^{\infty} (r+1)x^r$$

As we know,

$$\frac{1}{1-x} = 1 + x + x^2 + x^3 + x^4 + x^5 + \ldots\ldots$$

$$\frac{1}{1-x^2} = 1 + x^2 + x^4 + x^6 + x^8 + x^{10} + \ldots\ldots \quad \ldots(\text{i})$$

$$\frac{2x}{\left(1-x^2\right)^2} = 2x + 4x^3 + 6x^5 + 8x^7 + 10x^4 \ldots\ldots \quad \ldots(\text{ii})$$

Add equation (i) and (ii)

$$\frac{1}{1-x^2} + \frac{2x}{\left(1-x^2\right)^2} = 1 + 2x + x^2 + 4x^3 + x^4 + 6x^5 + x^6 + \ldots\ldots$$

$$\frac{1+x-x}{1-x^2}+\frac{2x}{\left(1-x^2\right)^2}=\sum_{r=0(\text{even})}^{\infty}x^r+\sum_{r=1(\text{odd})}^{\infty}(r+1)x^r$$

$$\Rightarrow \quad \frac{1+x}{1-x^2}-\frac{x}{1-x^2}+\frac{2x}{\left(1-x^2\right)^2}=G(x)$$

$$\Rightarrow \quad G(x)=\frac{1}{1-x}+\frac{x}{1-x^2}\left(-1+\frac{2}{1-x^2}\right)$$

$$\Rightarrow \quad \frac{1}{1-x}+\frac{x}{1-x^2}\left(\frac{-1+x^2+2}{1-x^2}\right)$$

$$\Rightarrow \quad \frac{1}{1-x}+\frac{x\left(1+x^2\right)}{\left(1-x^2\right)^2}$$

Question 26

Consider simple undirected graph with atleast 3 vertices, if A is adjacency matrix of graph then the number of 3-cycle is given by trace of

(A) $\frac{A^3}{3}$

(B) $\frac{A^3}{6}$

(C) A^3

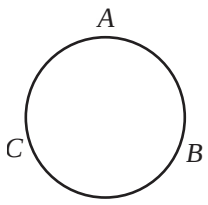
(D) $\frac{A^3}{2}$

Ans. **B**

Sol.

Diagonal element of A^3 gives number of paths of length 3, from any vertex to itself (cycle of 3).

For each participating vertex, each cycle will be counted thrice. As given below (ABCA, BCAB and CABC).



Furthermore, since the graph is undirected, every cycle will be counted twice. So overall every cycle of length 3 in A^3 will be counted 6 times, so we divide by 6 also. Therefore, the number of Cycle is trace of (A^3) / 6.

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Question 27

Which of the following is /are true for group G?

(A) If the order of G in 2, then G is commutative

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

(C) If G is commutative then a subgroup of G need not to be commutative

(D) If for all $x \in G$, $x^2 = 1$, then G in commutative, here 1 in identity element of G

Ans. **A,B,D**

Sol.

A. True

Theorem : All groups with less than 6 elements are abelian

B. True

To prove that G is an abelian group, we need $ab = ba$ for any elements *a.b* in *G*.

By the given relation, we have $(ab)^2 = a^2b^2$.

The left hand side is $(ab)^2 = (ab)(ab)$.

and thus the relation becomes $(ab)^2 = (ab) = a^2b^2$.

Equivalently. we can express it as $(ab)(ab) = aabb$.

Multiplying by a^{-1} on the left and $b^{-1}011$ the right, we obtain $a \sim^1 (abab)b \sim^I = a \sim^1 (aabb)b \sim^1$.

Since $a^{-1}a = e.\ bb^{-1} = e.$ where *e* is the identity element of *G*. $w^r e$ have $ebae = eabe.$

Since e is the identity element, it yields that $ba = ab$

and this implies that *G* is an abelian group.

C. False

Just use proof by contradiction.

Suppose *H* is not abelian and thus contains two non-commuting members *x* and *y*. Then $xy \wedge yx.$ But *x* and *y* are also in *G*. and thus *G* is not abelian.

Contradiction.

D. True

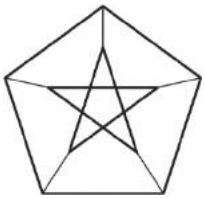
Whenever we have a condition $g^2 = e$ in a group, it's equivalent to $g = g^{-1}$ (multiply both sides by g^{-1}).

In this case, it applies to every element of the group, so we can add remove inverses from any expression freely. So the proof is simply

$$ab = (ab)^{-1} = b^{-1}a^{-1} = ba.$$

Question 28

Peterson graph is given below, for the given graph which of the following is correct?

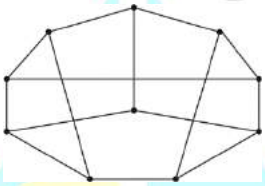


(A) Hamilton path exist in the given graph

(B) Chromatic number is 3

(C) Largest independent set has size 3

(D) Following graph is isomorphic to Peterson graph.

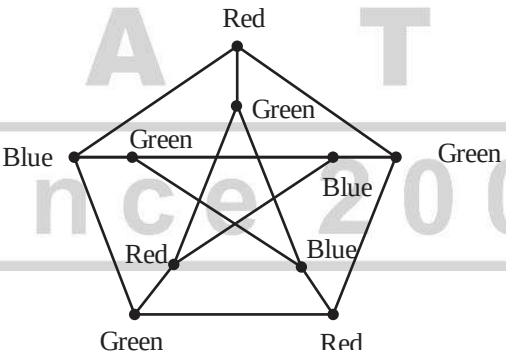


Ans. **A, B, D**

Sol.

A. True

B. True



C. False:

A set of vertices I is called an independent set if no two vertices in set I are adjacent to each other or in other words the set of non-adjacent vertices is called an independent set.

It is 4. From option B by simply keeping all the green vertices together we can simply observe that largest independent set contains 4 vertices.

D. True :

We can say given graphs are isomorphic if they have :

1. Equal number of vertices
2. Equal number of edges
3. Same degree sequence
4. Same number of circuit of particular length

Note : In most graphs checking the first three conditions is enough.

Question 29

The number of arrangement of 6 identical ball in 3 identical bins_____.

Ans. **7**

Sol.

It is the case of distribution with identical objects and identical boxes.

We simply need to partition number 6 in to maximum 3 parts and count the partition.

(6,0,0), (5,1,0), (4,2,0), (4,1,1), (3,2,0), (3,1,1), (2,2,2).

Algorithms

Question 30

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

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

(B) If the sum of all the elements of A is at most $2(n-1)$ then the graph must be acyclic

(C) If the graph is connected then none of the entries of $A^{n-1}+I_n$ can be zero

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

Ans. **A, C**

Sol.

Option A : True

Let's think about what $(A^2)_{i,i}$, the $i-th$ term on the diagonal is. We have

$$(A^2)_{ii}=(A\times A)_{ii}=\sum jA_i,\ {}_jA_{j,i}$$

But $A_{ij}=A_{j,i,}$ assuming that the graph is undirected, and $A_{ji}=1(i\sim j),$ *i.e.* is 1 is i and j are adjacent and 0 otherwise. Thus $A_{ij}A_{j,i}=A^2{}_{i,j}=A_{i,j}=1(i\sim j).$ So the sum is just the number of j such that $i\sim j,$ which precisely the degree is.

This work if vertices in your graph may have a single self-loop, provided you count that as 1 (not 2) for the degree. Indeed, the term in the sum when $j=i$ is just $A^2_{i,i,}$ but you need this to be equal to $A_{i,i}$. Thus it needs to be 0 or 1.

It does not work more generally, however, as $A^2_{ii} \neq A_{i,j}$ if $A_{i,j} > 1$.

$$(A^T A)_{i,j} = \sum_i A^2_{i,j} = \deg_{\text{out}}(i),$$

even for an undirected graph, provided the graph is simple.

Option : B False.

A cyclic graph is a graph containing at least one graph cycle. Consider a graph with 10 vertices where only three vertices form a cycle while reset are isolated vertices (that is a disconnected graph)

In such a case, sum of all the elements of A is $(1+1+1)=3$ and 3 is less than $2(10-1)=2*9=18$. But the graph is still cyclic.

Option C : True.

The matrix $A^{n-1}+I_n$ represents number paths upto length $n-1$ between pair of vertices, for a connected graph there will be at least one path between each pair of vertices, thus all entries of $A^{n-1}+I_n$ will be non zero.

Option D : False

Considering the following adjacency matrix :

	1	2	3	4
1	0	1	0	0
2	1	0	0	0
3	0	0	0	1
4	0	0	1	0

The corresponding graph is :

The graph is not connected

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Question 31

Consider the following recurrence:

$f(1)=1$

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

$f(2n+1)=2f(n)+1, \text{for } n\geq 1;$

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

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

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

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

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

Ans. **B,C,D**

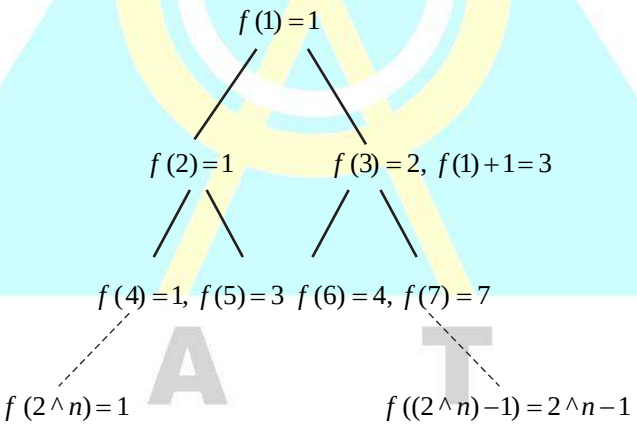
Sol.

$f(1)=1$

$f(2n)=2f(n)-1, \text{for } n\geq 1;$ {i.e. for even input to function f }

$f(2n+1)=2f(n)+1, \text{for } n\geq 1;$ {i.e. for odd input to function f }

Option C and D are true as given in the following diagram.



For option A,

$2^n+1=$ definitly odd

$\therefore \quad f(2^n+1)=2f(2^{n-1})+1$

$=2(1)+1 \qquad \{\text{As we know } f(2^{n-1})=1\}$

$=3$

Therefore A is false.

For option B,

5.2^n = Definitely even number for all $n \geq 1$

$f(5\cdot 2^n) = 2f(5\cdot 2^{n-1}) - 1$

$= 2\left(2f(5\cdot 2^{n-2}) - 1\right) - 1$

$= 2^2 f(5\cdot 2^{n-2}) - 2 - 1$

$= 2^2\left(2f(5\cdot 2^{n-3}) - 1\right) - 2 - 1$

$= 2^3 f(5\cdot 2^{n-3}) - 2^2 - 2 - 1$

$\vdots$

$= 2^n f(5\cdot 2^0) - 2^{n-1} - 2^{n-2} - 2^{n-3} \ldots - 2 - 1$

$= 2^n\left(f(5)\right) - \left(1 + 2 + 2^2 + \ldots 2^{n-2} + 2^{n-1}\right)$

$= 2^n(3) - (2^n - 1)$

$= 2^n(2+1) - (2^n - 1)$

$= 2^{n+1} + 2^n - 2^n + 1$

$= 2^{n+1} + 1$

Therefore B is false.

Q.32 Consider a simple undirected weighted graph G, all of whose edge weights are distinct. Which of the following statements about the MST of G is/are true?

(A) Suppose $S \subseteq V$ be such that $S \neq \theta$ and $S \neq V$. Consider the edge with min weight such that one of its vertices is in S and the other in V\S. Such an edge will always be part of any MST of G.

(B) G can have multiple spanning trees.

(C) One or both the edges with the third smallest and the fourth-smallest edges are part of any MST of G.

(D) The edge with the second-smallest weight is always part of any MST of G.

Ans. **A, C, D**

Sol. The smallest edge is always part of the MST. The graph does not have multiple spanning trees, as all the edge weights are unique. The second and third-smallest edge will be part of the MST if the number of vertices are greater than $n > 3$ and 4 respectively.

Q.33 Let G (V,E) be a directed graph $V = \{1,2,3,4,5\}$ is the set of vertices and E is the set of directed edges, as defined by the following adjacency matrix A :

$A[i][j] = 1,\ i <= j <= i < 5$

$A[i][j]=1$ indicates a directed edge from j to i

0, otherwise

A directed spanning tree of G, rooted at r t V is defined as a sub-graph of G such that the undirected version of T is a tree and T contains a directed path from r to every other vertex in V. The number of such directed spanning trees rooted at vertex 5 is_____

Ans. **24**

Sol. When we consider a graph of two elements, we get only 1 possible MST $(2->1)$ When we consider a graph of three elements, we get 2 possible MSTs $(3->1,3->2 \text{ or } 2->1,3->2)$. Similarly, When we consider a graph of four elements, we get only $3\times2\times1$ possible MSTs. Similarly. When we consider a graph of five elements, we get only $4\times3\times2\times1=24$ possible MSTs.

Question 34

Which one of the following statement is True and all positive functions $f(n)$?

(A) $f(n^2)=\Omega(f(n)^2)$

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

(C) $f(n^2)=\theta(f(n)^2)$, when $f(n)$ is a polynomial

(D) $f(n^2)=O(f(n)^2)$, when $f(n)$ is an exponential function.

Ans. **C**

Sol.

A: It need not be true for a function which is decreasing.

B: An exponential function may be increasing or decreasing, so this condition may not always be true.

C: It always holds because if we square the input variable, then the highest order in the polynomial will also get squared.

D: It is not true in cases when $f(n)$ is a polynomial function.

C Programming

Question 35

What is printed by ANSI C program?

```
#include <stdio.h>
int main (int argi, char* argv [])
{
    int x=1, z[2]={10,11};
    int *p = NULL;
     p= &x;
    *p = 10;
```

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```
    p = &z[1];
    *(& z [0]+1) +=3;
    printf("%d, %d, %d/n", x , z [0], z [1]);
    return 0;
}
```

(A) 10, 10, 14

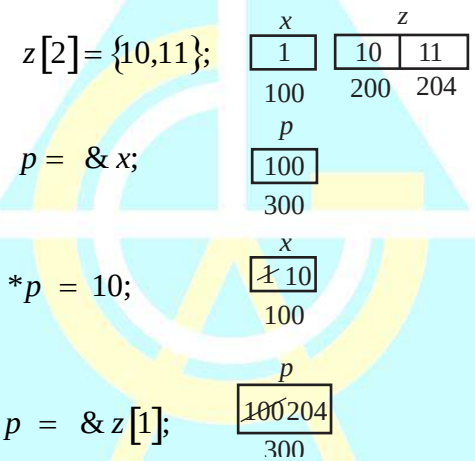
(B) 1, 10, 11

(C) 1, 10, 14

(D) 10, 14, 11

Ans. **A**

Sol.



*(& z [0]+1) +=3;

⇒ *(address of II[nd] element of array) + = 3;

⇒ i.e. add 3 to II[nd] element of array, therefore second elements becomes 14.

Hence, 10,10,14 gets printed.

Question 36

What is printed by ANSI C programme

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

```
        printf("%d", a [i][j][k]); printf("\n");}
    return 0;
}
```

Ans. **1 2 3**
10 11 12
19 20 21

Sol. $j = k = i = 0$

$a[3][3][3] = \{\{1, 2, 3, ...9\}, \rightarrow a[0]$ **(**First 2–D array)

$\{10, 11, ...18\}, \rightarrow a[1]$ (Second 2–D array)

$\{19, ...27\}\} \rightarrow a[2]$ (Third 2–D array)

In short, there are total third 2–D arrays, and in the code we need to find first row of each 2D array i.e.

1, 2, 3	First row of first 2-D array
10, 11, 12	First row of second 2-D array
19, 20, 21	First row of third 2-D array

Question 37

What is the output of given code?

```
char a = 'P';
char b = 'x';
char c = (a & b) + '*';
char d = (a | b) - '-';
char e = (a ^ b) + '+';
print f ("%c%c%c",c,d,e);
```

A	B	C	…	Z
65	66	67	…	90
a	b	c	…	z
97	98	99	…	122

*	+	–
42	43	45

Ans. **z, K, S**

Sol.

ASCII value of P = 80 and $x = 120$

$c = \underbrace{a \,\&\, b}_{\downarrow} + \underbrace{'*'}_{\downarrow}$

80 42 $\rightarrow 122 \Rightarrow z$

$d = \underbrace{a \mid b}_{\downarrow} - \underbrace{'-'}_{\downarrow}$

120 45 $\rightarrow 75 \Rightarrow K$

$e = \underbrace{a \hat{} b}_{\downarrow} + \underbrace{'+'}_{\downarrow}$

40 43 $\rightarrow 83 \Rightarrow S$

Data Structure

Question 38

Suppose binary search tree with 1000 distinct elements is also complete binary tree. The tree in sorted using array representation of Binary Heap Tree, Assuming that the array indices start with 0, the 3rd largest element of tree in sorted at index _____?

Ans. **509**

Sol.

The largest element in the BST is the right most element with index $510 (2^9 - 2$ as the indexing of the array is starting with 0) its parent is the second-largest element and its left child is the third-largest element which is of the index $510 - 1 = 509$.

Question 39

Suppose we are given n keys, m hash table slots and two simple uniform hash functions h_1 and h_2. Further suppose our hashing scheme uses h_1 for the odd keys and h_2 for the even keys. What is the expected no. of keys in a slot?

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

Ans. **A**

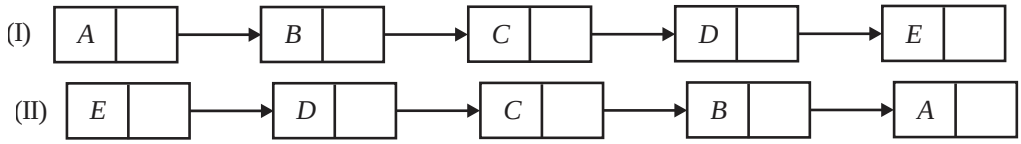
Sol.

Irrespective of the number of hash functions, the expected number of keys in a slot is given by (number of keys)/(number of slots) for a uniform hash function.

Question 40

Consider 2 linked list :

What is the time complexity to get reverse of linked I and II linked list by using best algorithm and space complexity $O(1)$.



(A) $O(1)$

(B) $O(n)$

(C) $O(n^2)$

(D) Not possible in space complexity $O(1)$

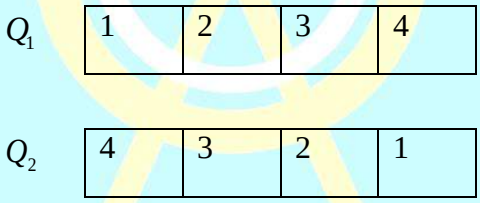
Ans. **B**

Sol.

Best algorithm for the problem takes O(n) in worst case.

Question 41

Consider two queue's Q_1 and Q_2 such that initially Q_1 contains 4 element {1, 2, 3, 4} and Q_2 is empty. What is the min number of enqueue operations needed on Q_1 to Q_2 in reverse order?



Ans. **6**

Sol.

This can be obtained by the following set of instructions

x = Dequeue ($Q1$)

Enqueue ($Q1$)

x = Dequeue ($Q1$)

Enqueue ($Q1$, x)

x = Dequeue ($Q1$)

Enqueue ($Q2$, x)

x = Dequeue ($Q1$)

Enqueue ($Q1$, x)

x = Dequeue ($Q1$)

Enqueue ($Q1$, x)

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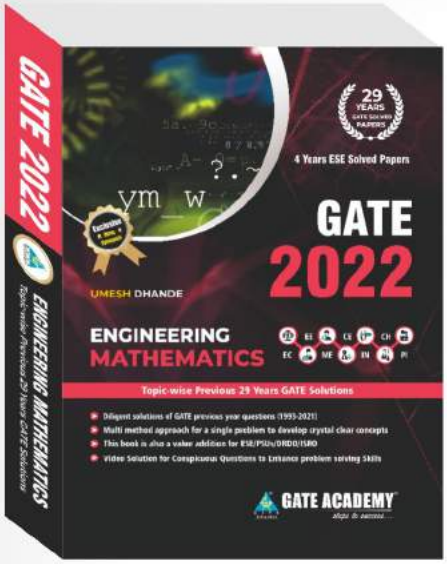

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3. Integral & Differential Calculus
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6. Mean Value Theorem
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10. Numerical Methods
11. Transform Theory
12. ESE Question [2017-2018]

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2. Logical Reasoning
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$x = \text{Dequeue}(Q1)$

Enqueue $(Q2, x)$

$x = \text{Dequeue}(Q1)$

Enqueue $(Q1, x)$

$x = \text{Dequeue}(Q1)$

Enqueue $(Q2, x)$

The number of enqueue operations on $Q1$ is $3+2+1=6$.

Operating System

Question 42

In the given table

Process P1	Process P2	Process P3
While (true)	While (true)	While
{	{	{
wait (S_3);	wait (S_1);	wait (S_2);
print "C"	print "B"	print "A"
Signal (S_2);	Signal (S_3);	Signal (S_1);
}	}	}

To get the output string of "BCABCABCA" the initial values of S_1, S_2 and S_3 are ?

Ans. **1,0,0**

Sol.

Initially if $S_1 = 1, S_2 = 0, S_3 = 0,$

Process P_2 can successfully execute wait (S_1); while P_1 and P_3 remain stuck at wait (S_3); and wait (S_2); respectively.

After process P_2 prints B it executes signal (S_3); and gets stuck at wait (S_1);

Here B gets printed in this process.

After this Process P_1 can successfully execute wait (S_3); and then it executes print("C");, after which it executes signal (S_2); and then gets stuck at wait (S_3);

Here C gets printed in this process.

After this Process P_3 can successfully execute wait (S_2): and then it executes print ("A");, after which it executes signal (S_1): and then gets stuck at wait (S_2);

Here A gets printed in this process.

After this Process P_2 can execute wait (S_1); successfully.

The process thus keeps repeating and the pattern printed is BCABCABCA…

Question 43

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

(A) $P=3, Q=7, R=7, S=3$

(B) $P=4, Q=10, R=6, S=2$

(C) $P=4, Q=12, R=5, S=4$

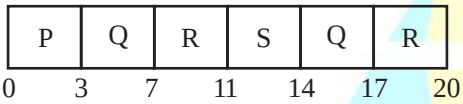
(D) $P=2, Q=9, R=5, S=1$

Ans. **A**

Sol.

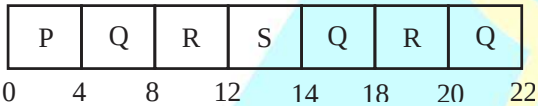
Valid Required Contexts switches are 1 – S to Q, 1 – R to Q, 2 – Q to R and no S to P.

A :



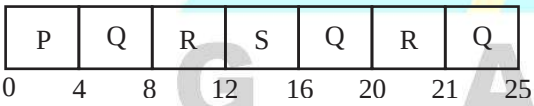
Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S and 1 – S to Q

B :



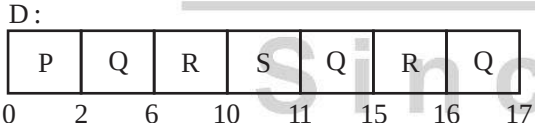
Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

C :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

D :



Contexts switches are 1 – P to Q, 2 – Q to R, 1 – R to S, 1 S to Q and 1 – R to Q

Hence, A is the correct option.

Question 44

Consider a demand paging system with four page frames (initially empty) and LRU page replacement policy. For the following page reference string 7, 2, 7, 3, 2, 5, 3, 4, 6, 7, 7, 1, 5, 6, 1 the page fault rate, defined as the ratio of number of page faults to the number of memory accesses. (2 decimal) is _____

Ans. **0.6**

Sol.

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

~~7~~	4	5
~~2~~	6	
~~3~~	1	
~~5~~	7	

Total page faults $=9$

Total Access $=15$

Thus page fault rate $=9/15=0.6$

Q.45 Consider two file-systems A and B. that use contiguous allocation and linked allocation respectively A file of size 100 blocks is already stored in A and also in B. Now, consider inserting a new block in the middle of the file (between 50th and 51st block), whose data is already available in the memory. Assume that there are enough free blocks at the end of the file and that the file control blocks are already in memory. Let the number of disk accesses required to insert a block in the middle of the file in A and B are n A and n E respectively, then the value of n_A+n_B is___.

2 Marks NAT

Ans. 153

Sol. For contiguous allocation, we have to store all the blocks in a sequence, if we have to store a block in the middle, we have to first shift all the blocks after that one place right, for which we need one disk read and one disk write for each block (2 disk accesses). Now since we are storing one block in contiguous allocation at 51^{st} position, the blocks (51^{st} to 100^{th}) have to be moved one step right, for which 2*50 disk accesses are required, then one access to store the new block, thus $n_A=100+1=101$.

In Linked allocation, we must read 50 blocks to find the middle. Then we must write the new block somewhere with the next block pointing to the block after the 50^{th} block. Then we must write the 50^{th} block to point to this new block, thus

$n_B=50+1+1=52$

Hence our required answer n_A+n_B is 153.

Q.46 Which of the following statements is False? **2 Marks MCQ**

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

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

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

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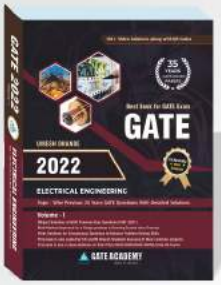

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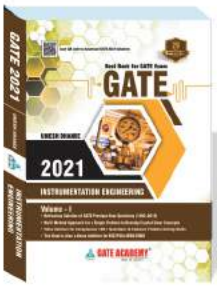

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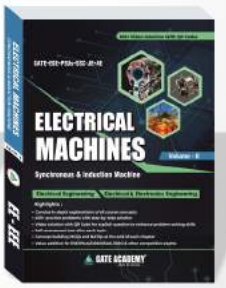

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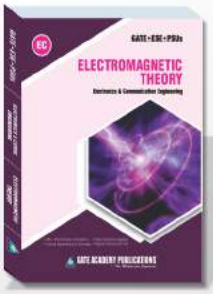

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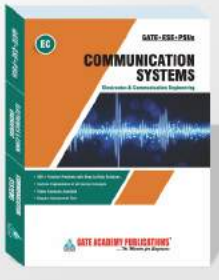


(D) The memory access time using a given inverted page table is always same for all incoming virtual addresses.

Ans. **D**

Sol. **A. True**

TLB Lookups:

1. Sequential search of the TLB
2. Direct mapping : assigns each virtual page to a specific slot in the TLB e.g., use upper bits of VPA to index TLB
3. Set associativity: use N TLB banks to perform lookups in parallel
4. Fully associative cache: allows looking up all TLB entries in parallel
5. Typically

   a. TLBs are small and fully associative

   b. Hardware caches use direct mapped or set-associative cache

B. True

A cache stores a copy of data from memory in a fast storage near the CPU. In case of TLB hit, we got the physical address (in main memory). We look into cache before accessing main memory. In case of a cache miss, we will definitely find the word in main memory as there was a TLB hit.

C. True

A hashed page table lookup may require many memory references to search the desired virtual address and its corresponding frame number because there is no guarantee on the number of entries in the linked list.

D. False

When a memory reference takes place, this virtual address is matched by the memory-mapping unit and the Inverted Page table is searched for a match and the corresponding frame number is obtained. If the match is found at the ith entry then the physical address of the process is sent as the real address otherwise if no match is found then Segmentation Fault is generated. Finding a match requires searching the entire table. Depending on the match, the memory access time will vary.

Q.47 Which of the following statements is/are TRUE with respect to deadlocks?

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

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

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

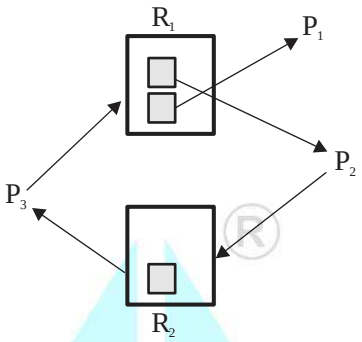
(D) If the current allocation of resources to processes leads the system to unsafe state then deadlock will necessarily occur.

Ans. **B, C**

Sol.

Option A:

A cycle exist in the system but since P_1 does not need any more resources it will finish after some time and P_3 will get resource R_1 this even in the presence of cycle the deadlock does not exist here



Option B:

When every edge is the assignment edge, that is, no process needs any more resources than the ones that are already allocated, thus deadlock doesn't exist here.

Option C:

Circular wait is a necessary condition for Deadlock but it is not sufficient. There are following 4 necessary conditions for the occurrence of deadlock

1. Mutual exclusion
2. Hold and wait
3. No preemption
4. Circular wait

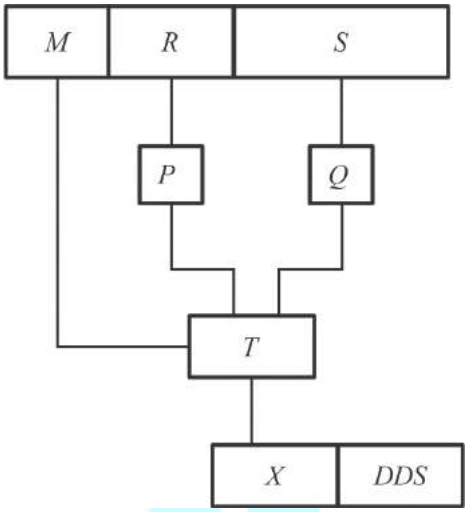
Option D:

Even if the allocation results in an unsafe state, some processes still may release the resources that are allocated to them for a while which may lead to elimination of deadlock from the system.

Digital Logic

Question 48

In a digital control system as shown in figure, a 16 bit code word is used to retrieve the value of X. The X will have the value of either of R or S depending on value of bit M (M is mode bit). Determine correct digital units P, Q and T. R denotes a memory containing 1024 words and S denotes a register file of size 32 registers.



(A) P is 10: 2^{10} decoder, Q is 5: 2^5 decoder, T is 2:1 Multiplexer

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

(C) P is 10: 1 Multiplexer, Q is 5: 1 Multiplexer, T is 2:1 Multiplexer

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

Ans. **A**

Sol. Based on the Address provided to P, one of the words of the memory unit S has to be selected. this function is performed by a Decoder r To be able to address 1024 words, we need 10 bits , and to select one out of 2^{10} addresses , we need 1G: 2^{10} Decoder which is unit P.

Similarly to decoder Address R we need 5: 2^5 Decoder.

Now one of the two inputs has to be selected to be loaded into X, selecting one input among many to place in the output. This function is performed by a Multiplexer here we need a 2x1 MUX. Hence A is the correct Answer.

Question 49

Which of the following give overflow. There are 4-bit register $R1$ and $R2$ and 2's compliment number system is used and Arithmetic addition $R1+R2$.

(A) 1001
1111

(B) 1100
1010

(C) 1011
1110

(D) 0011
0100

Answer: B

Sol.

We know that the range of 2"s complement numbers representable with 4 bits are -8 to +7.

A. R1 = -1*2^3 + 0*2^2 + 0*2^1 + 1*2^0 = -7

R2 = -1*2^3 +1*2^2 +1*2^1 + 1*2^0 = -1

R1 + R2 = -8 (no overflow)

B R1 = -1*2^3 + 1*2^2 + 0*2^1 + 0*2^0 = -4

R2 = -1*2^3 + 0*2^2 + 1*2^1 + 0*2^0 = -6

R1 + R2 = -10 (overflow)

C. R1 = -1*2^3 + 0*2^2 + 1*2^1 + 1*2^0 = -5

R2 = -1*2^3 + 1*2^2 + 1*2^A1 + 0*2^0 = -2

R1 + R2 = -7 (no overflow)

D R1 = 0*2^3 + 0*2^2 + 1*2^1 + 1*2^0 = 3

R2 = 0*2^3 + 1*2^2 + 0*2^1 + 0*2^0 = 4

R1 + R2 = 7 (no overflow)

Question 50

Floating point number A, B and C stored in registered $R_A R_B$ & R_C as per IEEE -754, The 32 bit content stored in these registered in hexadecimal form

$R_A = 0XC1400000$	$R_B = 0X\,42100000$	$R_C = 0X\,41400000$

Which is false

(A) $A + C = 0$

(B) $B = 3C$

(C) $C = A + B$

(D) $(B - C) > 0$

Ans. **C**

Sol. $A = 1100 \quad 0001 \quad 0100 \quad 0000$

$\text{Biased Exponent} = 130,\ \text{Exponent} = 130 - 127 = 3$

$\text{Decimal} = -1.1 \times 2^3 = -1100 = -12$

$B = 0100 \quad 0010 \quad 0001 \quad 0000$

$\text{Biased Exponent} = 132,\ \text{Exponent} = 132 - 127 = 5$

$\text{Decimal} = +1.001 \times 2^5 = 100100 = 36$

$C = 0100 \quad 0001 \quad 0100 \quad 0000$

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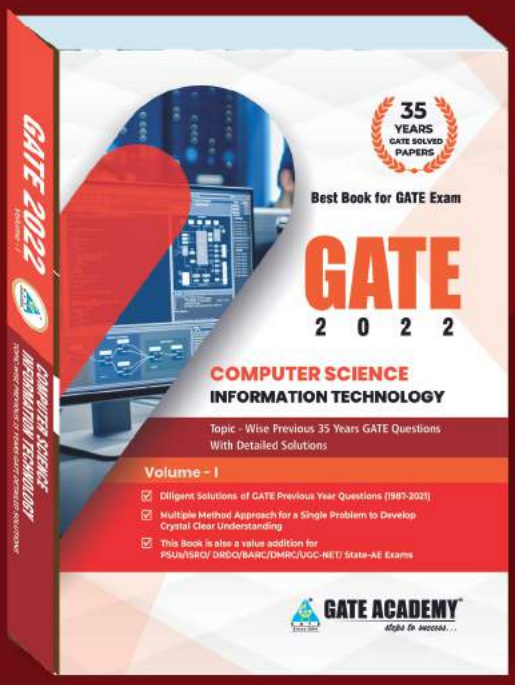

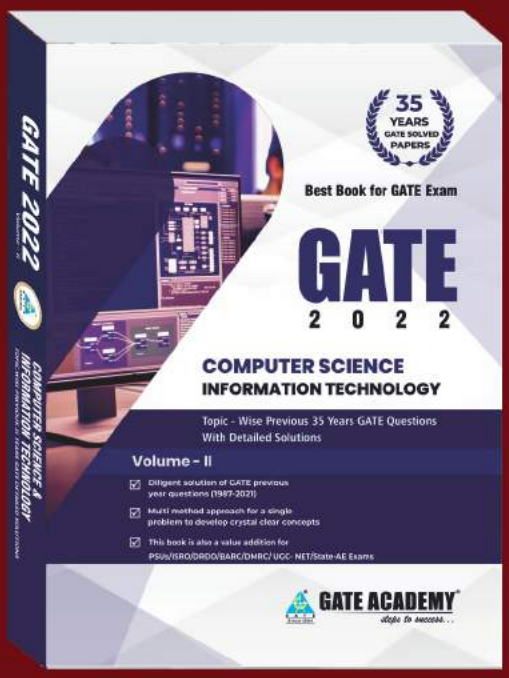

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5. Discrete Mathematics & Graph Theory
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2. Computer Organization & Architecture
3. Operating System
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Biased Exponent $=128+2=130$, Exponent $=130-122=3$

Decimal $=+1.1\times 2^3=1100=+12$

$A=-12$

$B=36$

$C=+12$

DBMS

Question 51

In relational data model which is true.

(A) A relation with only two attribute is always BCNF

(B) BCNF decomposition preserve functional dependencies

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

(D) If all attributes of a relation are prince attributes, then relation is in BCNF.

Ans. **A**

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

Question 52

Relation R (A, B, C, D, E) has 3 functional dependency:

$AB\rightarrow C,\ BC\rightarrow D,\ C\rightarrow E$

Find number of super keys?

Ans. **8**

Sol. R (A, B, C, D, E)

{

$AB\rightarrow C$

$BC\rightarrow D$

$C\rightarrow E$

}

Candidate key = AB

Number of super keys $=2^{5-2}=2^3=8$ super keys

Question 53

Consider relational database consisting of following for relations and respective schema with tuples.

Student (sno, sname, dno)

Department (dno, dname)

Course (cno, cname, dno)

Register (sno, dno)

Student

sno	sname	dno
S1	J	D01
S2	R	D01
S3	J	D02
S4	J	D01
S5	M	D03

Department

dno	dname
D01	CSE
D02	EEE

Course

cno	cname	dno
C_{11}	DS	D01
C_{12}	DS	D01
C_{21}	DE	D02
C_{22}	PT	D02
C_{23}	CV	D03

Register

sno	cno
S01	C_{17}
S01	C_{12}
S02	C_{11}
S03	C_{21}
S03	C_{22}
S03	C_{23}
S04	C_{11}
S04	C_{12}
S05	C_{11}
S05	C_{21}

Select * from student S where not exist (select cno from course where dno = "D01" except select cno, from register where sno = S.sno).

Ans. **2**

Sol. Select * from student S where not exist

((Select cno from course where dno = D01 except))

(Select cno from register where sno = S.sno)

The above query is co-related sub query so we need to execute inner query for every row of outer table.

Hence it gives 2 rows in output

S1	J	D01
S4	M	D03

Question 54

Let $R_i(z)$ and $W_i(z)$ denote read and write operations on data element z by a transaction T_1, consider schedule S with four transaction

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

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

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

Ans. **D**

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

T_1	T_2	T_3	T_4
			$R(x)$
	$R(x)$		
		$R(x)$	
$R(x)$			
$W(y)$			
	$W(x)$		
		$W(y)$	
			$R(y)$

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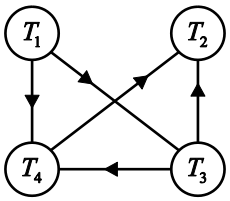


Apply topological sort then the sequence is

$T_1T_3T_4T_2$

Question 55

Employee (eid, Name)

Brand (bid, bName)

Own (eid, bid)

Return the set of eids who own all the brands.

(A) $\pi_{eid}(\pi_{eid,bid}(\text{Own}) / \pi_{bid}(\text{Brand}))$

(B) $\pi_{eid}(\pi_{eid,bid}(\text{Own}) / \pi_{bid}(\text{Own}))$

(C) $\pi_{eid}(\text{Own}) - \pi_{eid} / \pi_{eid}(\text{Own}) \times \pi_{bid}(\text{Brand}) - \pi_{eid,bid}(\text{Own}))$

(D) $\pi_{eid}(\pi_{eid}(\text{Own}) \times \pi_{bid}(\text{Own})) / \pi_{bid}(\text{Brand})$

Ans. **A, C**

Sol. Employee (eid, ename) Brand (bid, bname) Own (eid, eid)

To find set of eids who own all the brand we need to divide the table own by table brand like.

(A) $\pi_{eid}(\pi_{eid,bid}(\text{Own}) / \pi_{bid}(\text{Brand}))$ and the division operation can be represented using $(\times, -)$ operations like

(C) $\pi_{eid}(\text{Own}) - \pi_{eid} / \pi_{eid}(\text{Own}) \times \pi_{bid}(\text{Brand}) - \pi_{eid,bid}(\text{Own}))$

General Aptitude

Question 56

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

(A) Fare/Fair (B) Fair/ Fare (C) Faer/ Fair (D) Fare/fare

Ans. **A**

Sol. Fare : the amount of money you pay to travel by bus, train, taxi etc.

Fair : appropriate and acceptable in a particular situation the fare is high for it to be considered fair.

Here it is clearly seen that we are talking about amount, so first filler should be "fare" and from this option B and C are eliminated and second filler is given the sense of right, so it should be "fair"

Question 57

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

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

(A) 

(B) 

(C) 

(D) 

Ans. **A**

Sol. As we know, palindrome is word that mads the same forwards and backwards

RADAR is the only word. We have to rotate A and R 180^0 anticlockwise/clockwise.

Question 58

Let r be a root of the expression $x^2+2x+6=0$

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

(A) -51 (B) 126 (C) -126 (D) 51

Ans. **C**

Sol. $$x^2+2x+6=0$$

If r is root, then

$$r^2+2r+6=0$$

$$r^2+2r=-6 \quad \ldots \text{(i)}$$

Now, $(r+2)(r+3)(r+4)(r+5)$

$\Rightarrow$ $\{(r+2)(r+4)\}\{(r+3)(r+5)\}$

$\Rightarrow$ $(r^2+6r+8)(r^2+8r+15)$

$\Rightarrow$ $(r^2+2r+4r+8)(r^2+2r+6r+15)$

From (i), $r^2+2r=-6$

$\Rightarrow$ $(4r+2)(6r+9)$

$\Rightarrow$ $2(2r+1)3(2r+3)$

$\Rightarrow$ $6(2r+1)(2r+3)$

$\Rightarrow$ $6(4r^2+8r+3)$

From equation (i),

$$r^2+2r=-6$$

$$4(r^2+2r)=-24$$

$\Rightarrow$ $6(-24+3)$

$\Rightarrow$ $6(-21)$

$\Rightarrow$ -126

Question 59

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

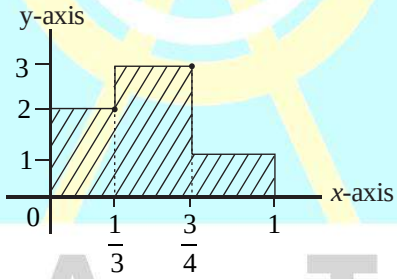
$$y(x)=\begin{cases}2 \text{ if } 0\le x\le\frac{1}{3}\\ 3 \text{ if } \frac{1}{3}\le x\le\frac{3}{4}\\ 1 \text{ if } \frac{3}{4}\le x\le 1\end{cases}$$

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

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

Ans. A

Sol. Graph of $y(x)$ *vs* x



Area of rectangle $=l\times b$

Area enclosed under the curve $=2\left(\frac{1}{3}-0\right)+3\left(\frac{3}{4}-\frac{1}{3}\right)+1\left(1-\frac{3}{4}\right)$

$\Rightarrow$ $\frac{2}{3}+\frac{5}{4}+\frac{1}{4}$

$\Rightarrow$ $=\frac{13}{6}$

Question 60

Given below are four statements

Statement 1 : All students are inquisitive

Statement 2 : Some students are inquisitive

Statement 3 : No students are inquisitive

Statement 4 : Some students are not inquisitive

For the given four statements, find the statements what cannot be true, simultaneously, assuming that there is at least one student in the class

(A) Statement 1 and Statement 3 (B) Statement 3 and Statement 4

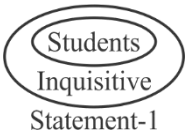
(C) Statement 2 and Statement 4 (D) Statement 1 and Statement 2

Ans. **A**

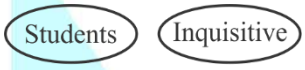
Sol.

As in the question, it is asked that statements that can not be true simultaneously

Option A

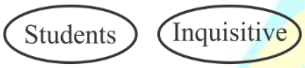


Statement-1



Statement-3

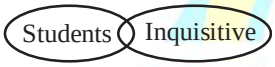
Option B



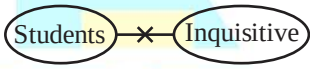
Statement-3

Statement-4

Option C

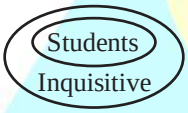


Statement-2



Statement-4

Option D



Statement-1

Statement-2

After making the venn diagram it is clearly visible that statement 1 and statement 3 cannot be possible simultaneously only one can possibly be happen at a time.

Question 61

A box contains five balls of same size and shape. Three of them are green coloured balls and two of them are orange coloured balls. Balls are drawn from the box one at a time. If a green ball is drawn it is not replaced. If an orange ball is drawn it is replaced with another orange ball. First ball is drawn. What is the probability of getting an orange ball in the next drawn ?

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

Ans. **A**

Sol.

In this we have two different cases

Case 1: 1 green and 1 orange ball

$$P(E)=\frac{3}{5}\times\frac{2}{4}=\frac{6}{20}$$

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TOPPER'S SPEAK

GATE 2020

I am very grateful to whole GATE ACADEMY team for helping me to build my concepts in all the subjects. For my success of AIR-1 there is immense role of Gate Academy. It was great learning & experience with the top most faculties of India. A special thanks to respected Umesh Dhande sir for creating such a wonderful platform for all GATE aspirants and Gurupal Chawla sir for motivating me at the time of failure.

I also want to thank Sujay sir, Saket sir, Das sir and Saurabh Sir for guiding me to take success steps towards my career.

To all the future GATE aspirants I would like to say, never give up on your dreams. Because it is our dreams that keep us alive.

GATE 2019

Hello Everyone! I am Rajat Soni. I secured AIR 1 in GATE 2019 in Electronics & Communication Engineering. I have completed my B.Tech in 2018 from NIT Warangal. It was 2017 when I came to know about GATE ACADEMY's YouTube channel. It helped me a lot for my preparation for GATE. Umesh Dhande Sir's YouTube videos on Control Systems really helped me to get a deeper insights in the subjects. Jasuja sir's videos on Digital Electronics and Gurupal sir's videos on Engineering Mathematics were very helpful for the last minute preparation. Also I have enrolled in the GATE ACADEMY's Online Test Series which helped me in analysis of my mistakes before GATE Examination. I owe a lot to GATE ACADEMY for their quality content on YouTube channel and very well designed Online Test Series.

GATE 2018

I thank Dhande sir for giving a kickstart to my GATE preparation. I was primarily focused on my research work and was not interested in the exam. Just before 4 months of Gate Examination, I came to know about Gate Academy's YouTube channel and in this way I started my preparation. Umesh Sir's video on Control Theory (especially the one on GM and PM) and Analog Circuits (especially Topology Concept and Gain Calulation Shortcuts) were insightful and conceptually sound. Also a lot of tricky questions were asked in the test series offered by Gate Academy and it gave me the necessary confidence for the exam. So I owe a lot to the Gate Academy's YouTube Channel and Gate Academy's test Series for my performance.

GATE 2017

I am very thankful to Dhande sir, Vishal sir, Sujay sir, Gurupal sir, Das sir and entire Gate academy team which helped me in building concepts and getting the numerical approach for Gate exam when I started my preparation.

For my success (AIR-1), there are a lot of people who have immense role and Gate Academy is on of them. For the aspiring students, I want to say that like you only I used to think how a topper looks like and now I know that, meaning that everyone has a topper in them you just need to believe in yourself to understand the concept, try to solve new questions through test series and don't act ideal on examination day.

If I can, then YOU WILL!

As we can't replace ball after getting green ball, so when we are drawing orange ball at that time we are left with only 4 balls in a box

Case 2: 1 orange and 1 orange ball

$$P(E)=\frac{2}{5}\times\frac{2}{5}=\frac{4}{25}$$

As with orange ball we can replace, so when we are drawing second orange ball at that time we have 5 balls in of box

P (getting an orange ball in the next drawn) = P (case 1 + case 2)

$$=\frac{6}{20}+\frac{4}{25}=\frac{23}{50}$$

Question 62

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

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

(A) Metrics are useful in organization with poor work culture
(B) Metrics are always counterproductive in organizations with good work culture
(C) Metrics are never useful in organization with good work culture
(D) Metrics are useful in organizations with good work culture

Ans. **D**

Sol. (A) Eliminated because Metrics are counterproductive in organization with poor work culture

(B) Eliminated because Metrics are counterproductive in organization with poor work culture not good work culture

(C) Eliminated because of the term "never" as Metrics are useful.

(D) Correct answer as Metrics are useful in organization with good work culture.

Question 63

The corners and the mid point of a triangle are name using distinct letters P,Q,R,S,T and U but not necessarily in the same order. Consider the following statements

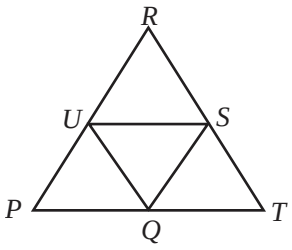
- The line joining P and R is parallel to the line joining Q and S
- P is placed on the side opposite to the corner T
- S and U cannot be placed in the same side

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

(A) P cannot be placed at a corner
(B) U cannot be placed at a mid point
(C) S cannot be placed at a corner
(D) R cannot be placed at a corner

Ans. **C**

Sol.



It satisfies all the given points.

$PR \| QS$

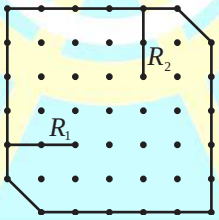
P is placed on the side opposite to the corner T

S and U cannot be placed in the same side

Question 64

A plot of land must be divided between four families. They instant their individual plots to be similar in shape, not necessarily in area. The land has equally spaced placed marked as dots on the below figure. Two ropes R_1 and R_2 are already present and cannot be moved.

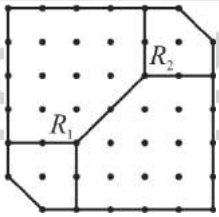
What is the least number of additional straight ropes needed to needs to divided plot ? A straight rope can pass through three poles that are aligned in a straight line



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

Ans. B

Sol.



Question 65

In a currently conducted National Entrance Test, Boys constituted 65% of those who appeared for the test. Girls constituted the remaining candidates and they accounted for 60% of the qualified candidates. Which one of the following is the correct logical inference based on the information provided in the above passage ?

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

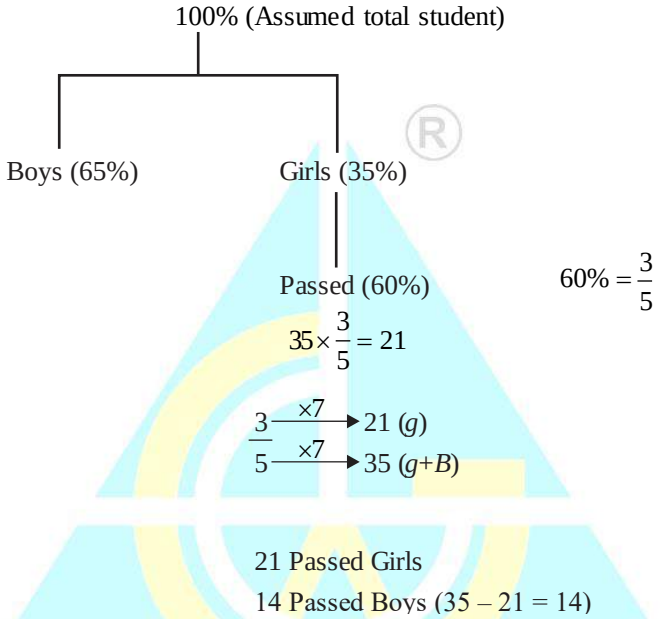
(B) The number of boys who qualified the test is less than the number of girls who qualified.

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

(D) Equal number of boys and girls qualified.

Ans. **B**

Sol.



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