ANALYSIS OF GATE 2016
Computer Science and Information Technology

Data Structure: 10%
GA: 15%
Design and Analysis of Algorithm: 9%
Operating System: 9%
DMGT: 7%
Digital: 3%
Computer Organization: 6%
DBMS: 5%
CN: 10%
TOC: 9%
CD: 3%
Maths: 14%
# GATE-2016- CS & IT 6 Feb 9 AM-12 PM

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<th>Topics Asked in Paper</th>
<th>Level of Toughness</th>
<th>Total Marks</th>
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<td>Compiler Design</td>
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<td><strong>Total</strong></td>
<td><strong>65</strong></td>
<td></td>
<td><strong>Moderate</strong></td>
<td><strong>100</strong></td>
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* Indicates Questions from New Syllabus

**Faculty Feedback:** Few questions came from New Syllabus; General Ability was pretty easy; many question from DSA & CN & TOC qualifying is easy but scoring is tough. Practice previous question papers will be beneficial.
GATE 2016 Examination
Computer Science Engineering

Test Date: 6/02/2016
Test Time: 9:00 AM 12:00 PM
Subject Name: Computer Science and Information Technology

Section: General Aptitude

Q.No. 1
Out of the following four sentences, select the most suitable sentence with respect to grammar and usage.

(A) I will not leave the place until the minister does not meet me.
(B) I will not leave the place until the minister doesn't meet me.
(C) I will not leave the place until the minister meet me.
(D) I will not leave the place until the minister meets me.

[Ans. D]
'until' itself is negative so it can't take one more negative i.e., 'does not'. Hence, Option (D) is the right answer.

Q.No. 2
A rewording of something written or spoken is a ________________.

(A) paraphrase  (B) paradox  (C) paradigm  (D) paraffin

[Ans. A]
'paraphrase' means a restatement of a text, passage or a rewording of something written or spoken.

Q.No. 3
Archimedes said, "Give me a lever long enough and a fulcrum on which to place it, and I will move the world."

The sentence above is an example of a __________ statement.

(A) figurative  (B) collateral
(C) literal  (D) figurine

[Ans. A]
'figurative' means representing by a figure or resemblance or expressing one thing in terms normally denoting another with which it may be regarded as analogous.
Q.No. 4

If ‘relftaga’ means carefree, ‘otaga’ means careful and ‘fertaga’ means careless, which of the following could mean ‘aftercare’?

(A) zentaga  (B) tagafer  (C) tagazen  (D) relffer

[Ans. C]
From given codes
Relftaga ⇒ carefree
Otaga ⇒ careful
Fertaga ⇒ careless
From these codes, clearly known that “care” means “taga,” from given alternatives, option ‘C’ is correct.

Q.No. 5

A cube is built using 64 cubic blocks of side one unit. After it is built, one cubic block is removed from every corner of the cube. The resulting surface area of the body (in square units) after the removal is _________.

(A) 56  (B) 64  (C) 72  (D) 96

[Ans. D]

From given data, 64 cubic blocks of one unit
Sizes are formed
No. of faces of the Cube is ‘6’
No. of corners of the Cube is ‘8’
After removing one Cubic block from Each corner,
The resulting surface area of the body = 6 × (4) = 96 sq. Units
Q.No. 6

A shaving set company sells 4 different types of razors, Elegance, Smooth, Soft and Executive. Elegance sells at Rs. 48, Smooth at Rs. 63, Soft at Rs. 78 and Executive at Rs. 173 per piece. The table below shows the numbers of each razor sold in each quarter of a year.

<table>
<thead>
<tr>
<th>Quarter \ Product</th>
<th>Elegance</th>
<th>Smooth</th>
<th>Soft</th>
<th>Executive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>27300</td>
<td>20009</td>
<td>17602</td>
<td>9999</td>
</tr>
<tr>
<td>Q2</td>
<td>25222</td>
<td>19392</td>
<td>18445</td>
<td>8942</td>
</tr>
<tr>
<td>Q3</td>
<td>28976</td>
<td>22429</td>
<td>19544</td>
<td>10234</td>
</tr>
<tr>
<td>Q4</td>
<td>21012</td>
<td>18229</td>
<td>16595</td>
<td>10109</td>
</tr>
</tbody>
</table>

Which product contributes the greatest fraction to the revenue of the company in that year?

(A) Elegance  (B) Executive  (C) Smooth  (D) Soft

Ans. B

Total No. of razors Elegance type from all four quarters = 27300 + 25222 + 28976 + 21012 = 10,2510
Total No. of razors of Smooth type from all four quarters = 20009 + 19392 + 22429 + 18229 = 8,0059
Total No. of razors of Soft type from all four Quarters = 17602 + 18445 + 19544 + 16595 = 7,2186
Total No. of razors of Executive type from all four Quarters = 9999 + 8942 + 10234 + 10109 = 3,9286

The revenue of the company in that year of 4 different types of razors
Elegance = 10,2510 \times 48 = 49,20,480
Smooth = 8,0059 \times 63 = 50,43,717
Soft = 7,2186 \times 78 = 56,30,508
Executive = 3,9284 \times 173 = 67,96,132

\therefore The Executive of razors contributes the greatest revenue of the company in that year.

Q.No. 7

Indian currency notes show the denomination indicated in at least seventeen languages. If this is not an indication of the nation’s diversity, nothing else is.

Which of the following can be logically inferred from the above sentences?

(A) India is a country of exactly seventeen languages.
(B) Linguistic pluralism is the only indicator of a nation’s diversity.
(C) Indian currency notes have sufficient space for all the Indian languages.
(D) Linguistic pluralism is strong evidence of India’s diversity.

Ans. D

If seventeen languages were not an indication of the nation’s diversity, nothing else is. If nothing else is so the best inference is option ‘D’.
Q.No. 8
Consider the following statements relating to the level of poker play of four players P, Q, R and S.

I. P always beats Q
II. R always beats S
III. S loses to P only sometimes
IV. R always loses to Q

Which of the following can be logically inferred from the above statements?

(i) P is likely to beat all the three other players
(ii) S is the absolute worst player in the set

(A) (i) only (B) (ii) only (C) (i) and (ii) (D) neither (i) nor (ii)

[Ans. D]

Q.No. 9
If \( f(x) = 2x^7 + 3x - 5 \), which of the following is a factor of \( f(x) \)?

(A) \((x^3+8)\)  (B) \((x-1)\)  (C) \((2x-5)\)  (D) \((x+1)\)

[Ans. B]
\( f(x) = 2x^7 + 3x - 5 \) for \( x = 1 \) the equation is satisfied. The factor is \((x-1)\).

Q.No. 10
In a process, the number of cycles to failure decreases exponentially with an increase in load. At a load of 80 units, it takes 100 cycles for failure. When the load is halved, it takes 10000 cycles for failure. The load for which the failure will happen in 5000 cycles is ________.

(A) 40.00  (B) 46.02  (C) 60.01  (D) 92.02

[Ans. B]
\[ \downarrow \text{load cycles for failure} \uparrow \text{exponentially} \]

Eg: load = \( x \)

Cycles for failure = \( y \)

\[ \frac{x}{2} = y^2, \frac{x}{3} = y^3, \frac{x}{4} = y^4 \]

\[ \therefore \text{Given at } x = 80, y = 100 \ldots \ldots (1) \]

at \( x = 40, y = (100)^{2/3} \ldots \ldots (2) \)

\[ \therefore \text{With decrease in load, Cycle for failure is increasing exponentially} \]

From (1) and (2), we can directly eliminate option A and D

Option (C)

Load = 60.01 units

\[ \frac{3}{4}(80 \text{ units}) = 60.01 \text{ units} \]

From the given relation

\[ \frac{3}{4}(80 \text{ units}) = (10)^{4/3} = (100)^{1} \times (100)^{1/3} = 100 \times 4.64 = 464 \]

It is not

\[ \therefore \text{Option (B) only possible} \]

\[ \therefore \text{At the load of 46.02 units, the failure will happen in 5000 cycles.} \]
Q.No. 1
Let \( p, q, r, s \) represent the following propositions.

\[ \begin{align*} 
 p: & \quad x \in \{8, 9, 10, 11, 12\} \\
 q: & \quad x \text{ is a composite number} \\
 r: & \quad x \text{ is a perfect square} \\
 s: & \quad x \text{ is a prime number} \\
\end{align*} \]

The integer \( x \geq 2 \) which satisfies \( \neg((p \Rightarrow q) \land (\neg r \lor \neg s)) \) is \( \text{________} \).

[Ans. *] Range: 11 to 11
\( \neg((p \Rightarrow q) \land (\neg r \lor \neg s)) \)
\( = (p \land \neg q) \lor (r \land s) \)
For \( x = 11 \), we have \( (p \land \neg q) \lor (r \land s) \) is TRUE.

Q.No. 2
Let \( a_n \) be the number of \( n \)-bit strings that do NOT contain two consecutive 1s. Which one of the following is the recurrence relation for \( a_n \)?

\( \begin{align*} 
 (A) & \quad a_n = a_{n-1} + 2a_{n-2} \\
 (B) & \quad a_n = a_{n-1} + a_{n-2} \\
 (C) & \quad a_n = 2a_{n-1} + a_{n-2} \\
 (D) & \quad a_n = 2a_{n-1} + 2a_{n-2} \\
\end{align*} \]

[Ans. B]

String
\( \lambda \) \quad \( a_0 = 1 \)
\( 0, 1 \) \quad \( a_1 = 2 \)
\( 01, 10, 11 \) \quad \( a_2 = 3 \)

\( \begin{align*} 
 (A) & \quad a_2 = a_1 + 2a_0 = 4 \\
 (B) & \quad a_2 = a_1 + a_0 = 3 \\
 (C) & \quad a_2 = 2a_1 + a_0 = 5 \\
 (D) & \quad a_2 = 2a_1 + 2a_0 = 6 \\
\end{align*} \)

Q.No. 3
\[ \lim_{x \to 4} \frac{\sin(x - 4)}{x - 4} = \text{________}. \]

[Ans. *] Range: 1 to 1
\[ \lim_{x \to 4} \frac{\sin(x - 4)}{x - 4} \]
Let \( x - 4 = t \)
\[ \Rightarrow \lim_{t \to 0} \frac{\sin t}{t} = 1 \]
Q.No. 4
A probability density function on the interval \([a, 1]\) is given by \(1/x^2\) and outside this interval the value of the function is zero. The value of \(a\) is ________.

[Ans. *] Range: 0.5 to 0.5

Given \(f(x) = \begin{cases} \frac{1}{x^2} & \text{for } a \leq x \leq 1 \\ 0 & \text{otherwise} \end{cases}\)

\[
\int_{-\infty}^{\infty} f(x)dx = 1 \Rightarrow \int_{a}^{1} \frac{1}{x^2} dx = 1
\]

\[
\left[-\frac{1}{x}\right]_{a}^{1} = 1 \Rightarrow \frac{1}{a} - 1 = 1
\]

\[
\Rightarrow a = \frac{1}{2} = 0.5
\]

Q.No. 5
Two eigenvalues of a \(3 \times 3\) real matrix \(P\) are \(2 + \sqrt{-1}\) and 3. The determinant of \(P\) is ________.

[Ans. *] Range: 15 to 15

If \(\lambda = 2 + \sqrt{-1} = 2 + i\) is an eigen value then \(2 - i\) is also eigen value

\[
\therefore |P| = (2 + i)(2 - i)3 = (4 + 1)3 = 15
\]

Q.No. 6
Consider the Boolean operator \(\#\) with the following properties:
\(x\#0 = x, x\#1 = \bar{x}, x\#x = 0\) and \(x\#\bar{x} = 1\). Then \(x\#y\) is equivalent to

A) \(x\bar{y} + \bar{x}y\)  
B) \(x\bar{y} + \bar{x}\bar{y}\)  
C) \(\bar{x}y + xy\)  
D) \(xy + \bar{x}\bar{y}\)

[Ans. A]
From the given data, properties of XOR GATE hence \(\#\) means XOR.

(OR)

\[
\# \text{ is equivalent to XOR operation.}
\]

\[
\therefore x\#y = x\bar{y} + \bar{x}y
\]

Q.No. 7
The 16-bit 2's complement representation of an integer is 1111 1111 1111 0101; its decimal representation is ________.

[Ans. *] Range: –11 to –11

Integer size is 16 bit, already it is given in its 2's complement notation; So, when it is 2's complemented once again it gives value. So answer is –11.
Q.No. 8
We want to design a synchronous counter that counts the sequence 0-1-0-2-0-3 and then repeats. The minimum number of J-K flip-flops required to implement this counter is ________.
[Ans.*] Range: 3 to 3

Q.No. 9
A processor can support a maximum memory of 4 GB, where the memory is word-addressable (a word consists of two bytes). The size of the address bus of the processor is at least ________ bits.
[Ans.*] Range: 31 to 31
Word size = 16 bit,
So memory size = $2^{31}$ words.
∴ 31 address bits are needed.

Q.No. 10
A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is CORRECT ($n$ refers to the number of items in the queue)?

(A) Both operations can be performed in $O(1)$ time

(B) At most one operation can be performed in $O(1)$ time but the worst case time for the other operation will be $\Omega(n)$

(C) The worst case time complexity for both operations will be $\Omega(n)$

(D) Worst case time complexity for both operations will be $\Omega(\log n)$

[Ans. A]
For ENQUEUE and DEQUEUE has no worst case/best case
Q.No. 11
Consider the following directed graph:

![Graph Diagram]

The number of different topological orderings of the vertices of the graph is ________.

[Ans. *] Range: 6 to 6
Since the graph has no cycle, so topological sorting is possible, which can be done from any node
so total number of topological ordering is 6

Q.No. 12
Consider the following C program.

```c
void f(int, short);
void main()
{
    int i = 100;
    short s = 12;
    short *p = &s;
    _________;  // call to f()
}
```

Which one of the following expressions, when placed in the blank above, will NOT result in
a type checking error?

(A) `f(s,*s)`
(B) `i = f(i, s)`
(C) `f(i,*s)`
(D) `f(i,*p)`

[Ans. D]
f(s, *s) since there is no pointer variable define with *s. So this function will give type checking
error.
i = f(i, s) since function prototype is void in void f (int, short) i.e., f is accepting argument int type
and short type and its return type should be integer because we store the output of function in
variable i which is integer type. So there must be type casting into integer type but type casting
is not present. So this function will give type checking error.
f(i, *s) since there is no pointer variable define with *s. So this function will give type checking
error.
f(i, *p) in this function to argument are pass one is int type and another is short type defined in
the main function. So this function will not give type checking error.
Q.No. 13

The worst case running times of Insertion sort, Merge sort and Quick sort, respectively, are:

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

[Ans. D]

Q.No. 14

Let $G$ be a weighted connected undirected graph with distinct positive edge weights. If every edge weight is increased by the same value, then which of the following statements is/are TRUE?

P: Minimum spanning tree of $G$ does not change
Q: Shortest path between any pair of vertices does not change

(A) P only
(B) Q only
(C) Neither P nor Q
(D) Both P and Q

[Ans. A]

Statement P: Since every edge weight is positive and we increase the value of every edge weight by same constant values. So minimum spanning tree of $G$ does not change.

Statement Q: Taking an example:

First path from ‘a’ to ‘c’ via ‘b’ have path value 3. But here path can be change ‘a’ to ‘e’ direct since paths value is same but path can be change. So statement is wrong.
Q.No. 15
Consider the following C program.

```c
#include<stdio.h>
void mystery(int *ptra, int *ptrb) {
    int *temp;
    temp = ptrb;
    ptrb = ptra;
    ptra = temp;
}
int main() {
    int a=2016, b=0, c=4, d=42;
    mystery(&a, &b);
    if (a < c)
        mystery(&c, &a);
    mystery(&a, &d);
    printf("%d\n", a);
}
```

The output of the program is __________

[Ans. *] Range: 2016 to 2016
Whatever modifications are performed in mystery ( ) function, those modifications are not reflected in main ( ) function so it will print 2016.

Q.No. 16
Which of the following languages is generated by the given grammar?

\[ S \rightarrow aS | bS | \epsilon \]

(A) \( \{a^n b^m | n, m \geq 0\} \)
(B) \( \{w \in \{a, b\}^* | w \text{ has equal number of a's and b's} \} \)
(C) \( \{a^n | n \geq 0\} \cup \{b^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\} \)
(D) \( \{a, b\}^* \)

[Ans. D]
Given grammar is
\[ S \rightarrow as|bs|\lambda \]
Which can give (ba, b, abab, .......)  
(A) Does not contain ba  
(B) Does not contain b  
(C) Does not contain abab
Q.No. 17
Which of the following decision problems are undecidable?

I. Given NFAs $N_1$ and $N_2$, is $L(N_1) \cap L(N_2) = \emptyset$?
II. Given a CFG $G = (N, \Sigma, P, S)$ and a string $x \in \Sigma^*$, does $x \in L(G)$?
III. Given CFGs $G_1$ and $G_2$, is $L(G_1) = L(G_2)$?
IV. Given a TM $M$, is $L(M) = \emptyset$?

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

[Ans. C]
I is decidable since we can construct product automata
II is a membership $x \in \epsilon \Sigma^* \epsilon \Sigma L(G)$ which is decidable for CFG
III not decidable due to PCP
IV not decidable due to church Turing thesis

Q.No. 18
Which one of the following regular expressions represents the language: the set of all binary strings having two consecutive 0s and two consecutive 1s?

(A) $(0+1)^*0011(0+1)^* + (0+1)^*1100(0+1)^*$
(B) $(0+1)^*(00(0+1)^*11 + 11(0+1)^*00)(0+1)^*$
(C) $(0+1)^*00(0+1)^* + (0+1)^*11(0+1)^*$
(D) $00(0+1)^*11 + 11(0+1)^*00$

[Ans. B]
(A) Does not contain 0101
(B) Is correct
(C) Can give 000
(D) Can give 1010
Q.No. 19
Consider the following code segment.

\[ \begin{align*}
x &= u - \tau; \\
y &= x \times v; \\
x &= y + w; \\
y &= t - z; \\
y &= x \times y; \\
\end{align*} \]

The minimum number of total variables required to convert the above code segment to static single assignment form is \(_{\text{________}}\).

[Ans. \_*] Range: 10 to 10

Q.No. 20
Consider an arbitrary set of CPU-bound processes with unequal CPU burst lengths submitted at the same time to a computer system. Which one of the following process scheduling algorithms would minimize the average waiting time in the ready queue?

(A) Shortest remaining time first  
(B) Round-robin with time quantum less than the shortest CPU burst  
(C) Uniform random  
(D) Highest priority first with priority proportional to CPU burst length

[Ans. A]
To minimize the average waiting time, we need to select the shortest remaining time process first, because all are arriving at the same time, and they have unequal CPU burst times. All other options will not minimize the waiting time. So, the answer is SRTF algorithm.

Q.No. 21
Which of the following is NOT a superkey in a relational schema with attributes \( V, W, X, Y, Z \) and primary key \( VY \)?

(A) \( VXYZ \)  
(B) \( VWXZ \)  
(C) \( VWXY \)  
(D) \( VWXYZ \)

[Ans. B]
A superkey is one which contains a candidate key.
Q.No. 22
Which one of the following is NOT a part of the ACID properties of database transactions?

(A) Atomicity
(B) Consistency
(C) Isolation
(D) Deadlock-freedom

[Ans. D]
A: Atomicity
C: Consistency
I: Isolation
D: Durability

Q.No. 23
A database of research articles in a journal uses the following schema.

\[(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, YEAR, PRICE)\]

The primary key is \((VOLUME, NUMBER, STARTPAGE, ENDPAGE)\) and the following functional dependencies exist in the schema.

\[(VOLUME, NUMBER, STARTPAGE, ENDPAGE) \rightarrow TITLE\]
\[(VOLUME, NUMBER) \rightarrow YEAR\]
\[(VOLUME, NUMBER, STARTPAGE, ENDPAGE) \rightarrow PRICE\]

The database is redesigned to use the following schemas.

\[(VOLUME, NUMBER, STARTPAGE, ENDPAGE, TITLE, PRICE)\]
\[(VOLUME, NUMBER, YEAR)\]

Which is the weakest normal form that the new database satisfies, but the old one does not?

(A) 1NF
(B) 2NF
(C) 3NF
(D) BCNF

[Ans. B]
\((Volume, Number) \rightarrow Year\) is a partial functional dependency. So, the given relation is in 1 NF but not in 2 NF.

Q.No. 24
Which one of the following protocols is NOT used to resolve one form of address to another one?

(A) DNS
(B) ARP
(C) DHCP
(D) RARP

[Ans. C]
DHCP is dynamic host configuration protocol: allocates one of the unused IP address
Q.No. 25
Which of the following is/are example(s) of stateful application layer protocols?
(i) HTTP
(ii) FTP
(iii) TCP
(iv) POP3

(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (ii) and (iv) only
(D) (iv) only

[Ans. C]
POP 3 and FTP are stateful application layer protocols.

Q.No. 26
The coefficient of $x^{12}$ in $(x^3 + x^4 + x^5 + x^6 + \ldots)^3$ is ________.

[Ans.*] Range: 10 to 10

$\left( x^3 + x^4 + x^5 + x^6 + \ldots \right)^3 = x^9(1 + x + x^2 + x^3 + \ldots)^3$

$= x^9\left( (1-x)^{-1} \right)^3 = x^9(1-x)^{-3} = x^9 \sum_{n=0}^{\infty} C(n+2,2)x^n$

Coefficient of $x^{12} = C(5,2) = 10$

Q.No. 27
Consider the recurrence relation $a_1 = 8$, $a_n = 6n^2 + 2n + a_{n-1}$. Let $a_{99} = K \times 10^4$. The value of $K$ is ________.

[Ans.*] Range 197.9 to 198.1

$a_1 = 8 = 6.1^2 + 2.1$
$a_2 = 6.2^2 + 2.2 + a_1$
$= 6(1^2 + 2^2) + 2(1 + 2)$
$a_3 = 6(1^2 + 2^2 + 3^2) + 2(1 + 2 + 3)$
$a_{99} = 6(1^2 + 2^2 + 3^2 + \ldots + 99^2) + 2(1 + 2 + 3 + \ldots + 99)$

$= 6 \times 99 \times 100 \times (2 \times 99 + 1) \times 2 \times 99 \times 100$

$= 9900(199) + 9900$

$= 9900(199 + 1) = 99 \times 2 \times 10^4 = 198$
Q.No. 28
A function \(f : \mathbb{N}^+ \rightarrow \mathbb{N}^+\), defined on the set of positive integers \(\mathbb{N}^+\), satisfies the following properties:

\[
\begin{align*}
    f(n) &= f(n/2) & \text{if } n \text{ is even} \\
    f(n) &= f(n + 5) & \text{if } n \text{ is odd}
\end{align*}
\]

Let \(R = \{i \mid \exists j : f(j) = i\}\) be the set of distinct values that \(f\) takes. The maximum possible size of \(R\) is ________.

\[\text{[Ans. *]} \text{ Range: 2 to 2} \]
\[f(n) \begin{cases} 
    f\left(\frac{n}{2}\right), & \text{if } n \text{ is even} \\
    f(n + 5), & \text{if } n \text{ is odd}
\end{cases} \]

Using the definition of the function we can show that

\[
\begin{align*}
    f(1) = f(2) = f(3) = f(4) = f(6) = f(7) = f(8) = f(9) \ldots \\
    \text{and } f(5) = f(10) = f(15) = f(20) = \ldots
\end{align*}
\]

\[\therefore \text{The range of } f(n) \text{ contain two distinct elements.}\]

Q.No. 29
Consider the following experiment.

\[\text{Step 1. Flip a fair coin twice.} \]
\[\text{Step 2. If the outcomes are (TAILS, HEADS) then output } Y \text{ and stop.} \]
\[\text{Step 3. If the outcomes are either (HEADS, HEADS) or (HEADS, TAILS), then output } N \text{ and stop.} \]
\[\text{Step 4. If the outcomes are (TAILS, TAILS), then go to Step 1.} \]

The probability that the output of the experiment is \(Y\) is (up to two decimal places) ________.

\[\text{[Ans. *] Range: 0.33 to 0.34} \]

The possibilities are

\[
P(Y) = \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} + \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} + \ldots = \frac{\frac{1}{4}}{1 - \frac{1}{4}} = \frac{1}{3} = 0.33
\]

<table>
<thead>
<tr>
<th>1st time</th>
<th>H</th>
<th>H</th>
<th>T</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd time</td>
<td>H</td>
<td>T</td>
<td>H</td>
<td>T</td>
</tr>
</tbody>
</table>

\[\therefore \text{The range of } f(n) \text{ contains two distinct elements.}\]
Q.No. 30
Consider the two cascaded 2-to-1 multiplexers as shown in the figure.

The minimal sum of products form of the output \(X\) is

- (A) \(P\bar{Q} + PQR\)
- (B) \(PQ + QR\)
- (C) \(PQ + \bar{P}\bar{Q}R\)
- (D) \(Q\bar{R} + PQR\)

[Ans. D]
Output of first mux \(y = PR\)
Output of second mux \(x = Q\bar{R} + QY = Q\bar{R} + QPR\)

Q.No. 31
The size of the data count register of a DMA controller is 16 bits. The processor needs to transfer a file of 29,154 kilobytes from disk to main memory. The memory is byte addressable. The minimum number of times the DMA controller needs to get the control of the system bus from the processor to transfer the file from the disk to main memory is 

[Ans. *] Range: 456 to 456
Terminal Count Register size = 16 bit.
So, for one transfer operation of 64 KB, the register content will become zero, so, number of times the content of the register to be filled is

\[
\frac{29154\text{ KB}}{64\text{ KB}} = 455.35 \approx 456
\]
Q.No. 32
The stage delays in a 4-stage pipeline are 800, 500, 400 and 300 picoseconds. The first stage (with delay 800 picoseconds) is replaced with a functionally equivalent design involving two stages with respective delays 600 and 350 picoseconds. The throughput increase of the pipeline is __________ percent.

[Ans. *] Range: 33 to 34
Old pipeline maximum delay = 800 ns
New pipeline maximum delay = 600 ns
800 : 600 = 4:3
Increasing throughput = \( \frac{4 - 3}{3} = 33.3\% \)

Q.No. 33
Consider a carry lookahead adder for adding two \( n \)-bit integers, built using gates of fan-in at most two. The time to perform addition using this adder is

\[
(A) \ \Theta(1) \\
(B) \ \Theta(\log(n)) \\
(C) \ \Theta(\sqrt{n}) \\
(D) \ \Theta(n)
\]

[Ans. B]
Size of the integer = \( n \) bit and maximum number of inputs to the gate is two. So, time is depending on size.
Q.No. 34

The following function computes the maximum value contained in an integer array \( p[] \) of size \( n \) \((n \geq 1)\).

```c
int max(int *p, int n) {
    int a=0, b=n-1;
    while (__________) {
        if (p[a] <= p[b]) { a = a+1; }
        else { b = b-1; }
    }
    return p[a];
}
```

The missing loop condition is

(A) \( a \neq n \)
(B) \( b \neq 0 \)
(C) \( b > (a + 1) \)
(D) \( b \neq a \)

[Ans. D]

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

\( a = 0, b = 3 \)
\( a = 0 \) \( P[0] > P[3], b = 2 \)
\( a = 0 \) \( P[0] > P[2], b = 1 \) Stoping condition is \( b! = a \)
\( a = 0 \) \( P[0] > P[1], b = 1 \)
So return \( P[a] = 5 \)
Q.No. 35
What will be the output of the following C program?

```c
void count(int n){
    static int d=1;
    printf("%d ", n);
    printf("%d ", d);
    d++;
    if(n>1) count(n-1);
    printf("%d ", d);
}

void main(){
    count(3);
}
```

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

[Ans. A]
Q.No. 36
What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

\[
\begin{align*}
&\text{a}=3; \\
&\text{void n(x) \{x = x * a; print(x);\}} \\
&\text{void m(y) \{a = 1; a = y - a; n(a); print(a);\}} \\
&\text{void main() \{m(a);\}}
\end{align*}
\]

(A) 6, 2
(B) 6, 6
(C) 4, 2
(D) 4, 4

[Ans. D]

Q.No. 37
An operator delete(i) for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

(A) \(O(1)\)
(B) \(O(d)\) but not \(O(1)\)
(C) \(O(2^d)\) but not \(O(d)\)
(D) \(O(d 2^d)\) but not \(O(2^d)\)

[Ans. B]
It is not mentioned heap min or max although to delete a element Time complexity is \(O(d)\) is both cases and seeing the options (B) is more appropriate
Q.No. 38
Consider the weighted undirected graph with 4 vertices, where the weight of edge \( \{i, j\} \) is given by the entry \( W_{ij} \) in the matrix \( W \).

\[
W = \begin{bmatrix}
0 & 2 & 8 & 5 \\
2 & 0 & 5 & 8 \\
8 & 5 & 0 & x \\
5 & 8 & x & 0
\end{bmatrix}
\]

The largest possible integer value of \( x \), for which at least one shortest path between some pair of vertices will contain the edge with weight \( x \) is ________.

[Ans. *] Range: 12 to 12

Q.No. 39
Let \( G \) be a complete undirected graph on 4 vertices, having 6 edges with weights being 1, 2, 3, 4, 5, and 6. The maximum possible weight that a minimum weight spanning tree of \( G \) can have is ________.

[Ans. *] Range 7 to 7

Since \( G \) is a complete graph so \( G \) is 4 vertex 6 edges

So in the given graph cycle will be formed when we take three vertices so 1, 2 are selected now if '3' form a cycle then, but 4 will not for a cycle so \( 1 + 2 + 4 = 7 \)
Q.No. 40

\( G = (V, E) \) is an undirected simple graph in which each edge has a distinct weight, and \( e \) is a particular edge of \( G \). Which of the following statements about the minimum spanning trees (MSTs) of \( G \) is/are TRUE?

I. If \( e \) is the lightest edge of some cycle in \( G \), then every MST of \( G \) includes \( e 

II. If \( e \) is the heaviest edge of some cycle in \( G \), then every MST of \( G \) excludes \( e 

(A) I only  (B) II only  (C) both I and II  (D) neither I nor II

[Ans. B]

Q.No. 41

Let \( Q \) denote a queue containing sixteen numbers and \( S \) be an empty stack. \( \text{Head}(Q) \) returns the element at the head of the queue \( Q \) without removing it from \( Q \). Similarly \( \text{Top}(S) \) returns the element at the top of \( S \) without removing it from \( S \). Consider the algorithm given below.

```
while Q is not Empty do
    if S is Empty OR Top(S) \leq \text{Head}(Q) then
        x := \text{Dequeue}(Q);
        \text{Push}(S,x);
    else
        x := \text{Pop}(S);
        \text{Enqueue}(Q,x);
    end
end
```

The maximum possible number of iterations of the while loop in the algorithm is __________.

[Ans. *] Range: 256 to 256

The minimum number of iterations of the while loop in algorithm when use take queue contain element in ascending order i.e., 1, 2, 3, 4, \ldots, 16 is 16. The maximum number of iterations of while loop in algorithm when we take queue containing elements in descending order i.e., 16, 15, 14, \ldots, 1. First 16 will push into stack and then enqueue it in the end of the queue. This process do till we get 1 as head element. When head point to 1 then simple push the 1 in stack. In this manner we have to push all element in stack in as-sending order, until queue is empty it will take 256 of iterations.

Example

For \( n = 3 \)

```
3 2 1
Head  Rear
```
Sequence of operation with while loop execution.

<table>
<thead>
<tr>
<th></th>
<th>1. dequeue (3)</th>
<th>2. pop (3)</th>
<th>3. dequeue (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>push (3)</td>
<td>enqueue (3)</td>
<td>push (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. pop (2)</td>
<td>enqueue (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enqueue (2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. pop (3)</td>
<td>enqueue (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>enqueue (3)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

So for \( n = 3 \) it takes \( 3 \times 3 = 9 \) iterations of while loop in algorithm. So, for \( n = 16 \) it will take \( 16 \times 16 = 256 \) iterations of while loop.

Q.No. 42

Consider the following context-free grammars:

\[ G_1: S \rightarrow aS | B, \quad B \rightarrow b | bB \]

\[ G_2: S \rightarrow aA | bB, \quad A \rightarrow aA | B | \epsilon, \quad B \rightarrow bB | \epsilon \]

Which one of the following pairs of languages is generated by \( G_1 \) and \( G_2 \), respectively?

- (A) \( \{a^m b^n | m > 0 \text{ or } n > 0 \} \) and \( \{a^m b^n | m > 0 \text{ and } n > 0 \} \)
- (B) \( \{a^m b^n | m > 0 \text{ and } n > 0 \} \) and \( \{a^m b^n | m > 0 \text{ or } n \geq 0 \} \)
- (C) \( \{a^m b^n | m \geq 0 \text{ or } n > 0 \} \) and \( \{a^m b^n | m > 0 \text{ and } n > 0 \} \)
- (D) \( \{a^m b^n | m \geq 0 \text{ and } n > 0 \} \) and \( \{a^m b^n | m > 0 \text{ or } n > 0 \} \)

[Ans. D]

\[ G_1: S \rightarrow aS | B, \quad B \rightarrow b | bB \]

\[ S \rightarrow aS \rightarrow aaS \rightarrow aaB \rightarrow aab \]

\[ S \rightarrow aaB \rightarrow ab \rightarrow aabB \rightarrow aab \]

\[ S \rightarrow B \rightarrow b \]

So for \( a^m b^n \) \( m \) can be zero so (A) and (B) are false now in option (C) if \( m \geq 0 \) then \( n = 0 \) which is not possible so (D) is correct.
Q.No. 43
Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{X, Z\}$. $Z$ is the initial stack symbol. Let $L$ denote the language accepted by the PDA.

Which one of the following is TRUE?

(A) $L = \{a^n b^n | n \geq 0\}$ and is not accepted by any finite automata
(B) $L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$ and is not accepted by any deterministic PDA
(C) $L$ is not accepted by any Turing machine that halts on every input
(D) $L = \{a^n | n \geq 0\} \cup \{a^n b^n | n \geq 0\}$ and is deterministic context-free

[Ans. D]

Q.No. 44
Let $X$ be a recursive language and $Y$ be a recursively enumerable but not recursive language. Let $W$ and $Z$ be two languages such that $Y$ reduces to $W$, and $Z$ reduces to $X$ (reduction means the standard many-one reduction). Which one of the following statements is TRUE?

(A) $W$ can be recursively enumerable and $Z$ is recursive.
(B) $W$ can be recursive and $Z$ is recursively enumerable.
(C) $W$ is not recursively enumerable and $Z$ is recursive.
(D) $W$ is not recursively enumerable and $Z$ is not recursive.

[Ans. C]
$X$ is REC, $Y$ is RE not REC so $\overline{Y}$ is not RE
$\overline{Y} \leq W, Z \leq \overline{X}$
Since $\overline{Y}$ is nor RE so $W$ is not
$Z \leq \overline{X}$, so $Z$ is REC
Q.No. 45
The attributes of three arithmetic operators in some programming language are given below.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Precedence</th>
<th>Associativity</th>
<th>Arity</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>High</td>
<td>Left</td>
<td>Binary</td>
</tr>
<tr>
<td>−</td>
<td>Medium</td>
<td>Right</td>
<td>Binary</td>
</tr>
<tr>
<td>*</td>
<td>Low</td>
<td>Left</td>
<td>Binary</td>
</tr>
</tbody>
</table>

The value of the expression \(2 - 5 + 1 - 7 \times 3\) in this language is ________.

[Ans. *] Range 9 to 9
\[
2 - 5 + 1 - 7 \times 3 = 2 - 6 - 7 \times 3 = 2 + 1 \times 3 = 3 \times 3 = 9
\]

Q.No. 46
Consider the following Syntax Directed Translation Scheme (SDTS), with non-terminals \(\{S, A\}\) and terminals \(\{a, b\}\).

\[
\begin{align*}
S & \rightarrow aA \{ \text{print 1} \} \quad (1) \\
S & \rightarrow a \quad \{ \text{print 2} \} \quad (2) \\
A & \rightarrow Sb \quad \{ \text{print 3} \} \quad (3)
\end{align*}
\]

Using the above SDTS, the output printed by a bottom-up parser, for the input \(aab\) is:

(A) 1 3 2
(B) 2 2 3
(C) 2 3 1
(D) syntax error

[Ans. C]

\[
\begin{align*}
S & \rightarrow aA \quad \{ \text{print 1} \} \quad \ldots \ldots \quad (1) \\
S & \rightarrow a \quad \{ \text{print 2} \} \quad \ldots \ldots \quad (2) \\
A & \rightarrow Sb \quad \{ \text{print 3} \} \quad \ldots \ldots \quad (3)
\end{align*}
\]
Q.No. 47
Consider a computer system with 40-bit virtual addressing and page size of sixteen kilobytes. If the computer system has a one-level page table per process and each page table entry requires 48 bits, then the size of the per-process page table is ______ megabytes.

[Ans. *] Range: 384 to 384
Page table size = Number of entries in page table × Page table entry size
= \( \left( \frac{2^{40}}{2^{14}} \right) \times 48 \) bits
= \( 2^{26} \times 6 \) bytes
= \( 64 \text{ M} \times 6 \text{ B} = 384 \)

Q.No. 48
Consider a disk queue with requests for I/O to blocks on cylinders 47, 38, 121, 191, 87, 11, 92, 10. The C-LOOK scheduling algorithm is used. The head is initially at cylinder number 63, moving towards larger cylinder numbers on its servicing pass. The cylinders are numbered from 0 to 199. The total head movement (in number of cylinders) incurred while servicing these requests is ______.

[Ans. *] Range 346 to 346

\[
\begin{align*}
C &- Look \\
10 & 11 \ 38 \ 47 \ 63 \ 87 \ 92 \ 121 \ 191 \\
(87 - 63) \ + \ (92 - 87) \ + \ (121 - 92) \ + \ (191 - 121) \ + \ (191 - 10) \ + \ (11 - 10) \ + \ (38 - 11) \ + \ (47 - 38) \ &= 24 + 5 + 29 + 70 + 181 + 1 + 27 + 9 = 346
\end{align*}
\]

Q.No. 49
Consider a computer system with ten physical page frames. The system is provided with an access sequence, \( a_1, a_2, \ldots, a_{20}, a_1, a_2, \ldots, a_{20} \), where each \( a_i \) is a distinct virtual page number. The difference in the number of page faults between the last-in-first-out page replacement policy and the optimal page replacement policy is ______.

[Ans. *] Range 1 to 1
This question is little tricks, but not difficult. You can solve the problem by taking smaller example with smaller values.
Example: 1, 2, 3, 4, 1, 2, 3, 4 with '2' frames
LIFO: 1, 2, 3, 4, 1, 2, 3, 4

\[
\begin{array}{cccccccccc}
\ & \ & \ & \ & \ & \ & \ & \ & \ & \\
\ & \ & \ & \ & \ & \ & \ & \ & \ & \\
1 & F & F & F & F & F & F & 3 & 4 & \\
1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & \\
\end{array}
\]

Total page faults = 7
Optimal: 1, 2, 3, 4, 1, 2, 3, 4

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>X</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td></td>
<td>F</td>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Total page faults = 6
7 - 6 = 1.

Q.No. 50

Consider the following proposed solution for the critical section problem. There are \( n \) processes: \( P_0 \ldots P_{n-1} \). In the code, function \( p_{\text{max}} \) returns an integer not smaller than any of its arguments. For all \( i \), \( t[i] \) is initialized to zero.

Code for \( P_i \):

\[
\text{do} \{ \\
\quad c[i]=1; \ t[i] = p_{\text{max}}(t[0], \ldots, t[n-1])+1; \ c[i]=0; \\
\quad \text{for every } j \neq i \text{ in } \{0, \ldots, n-1\} \{ \\
\quad \quad \text{while (c[j])}; \\
\quad \quad \text{while (t[j] != 0 && t[j]<t[i]);} \\
\quad \} \\
\quad \text{Critical Section;} \\
\quad t[i]=0; \\
\quad \text{Remainder Section;} \\
\} \text{ while (true);}
\]

Which one of the following is TRUE about the above solution?

(A) At most one process can be in the critical section at any time
(B) The bounded wait condition is satisfied
(C) The progress condition is satisfied
(D) It cannot cause a deadlock

[Ans. A]

It satisfies the mutual exclusion, so only one process can be in the critical section at any time.
Q.No. 51
Consider the following two phase locking protocol. Suppose a transaction $T$ accesses (for read or write operations), a certain set of objects $\{O_1, \ldots, O_k\}$. This is done in the following manner:

Step 1. $T$ acquires exclusive locks to $O_1, \ldots, O_k$ in increasing order of their addresses.
Step 2. The required operations are performed.
Step 3. All locks are released.

This protocol will

(A) guarantee serializability and deadlock-freedom
(B) guarantee neither serializability nor deadlock-freedom
(C) guarantee serializability but not deadlock-freedom
(D) guarantee deadlock-freedom but not serializability

[Ans. A]

Q.No. 52
Consider that B wants to send a message $m$ that is digitally signed to A. Let the pair of private and public keys for A and B be denoted by $K^-_x$ and $K^+_x$ for $x = A, B$, respectively. Let $K_x(m)$ represent the operation of encrypting $m$ with a key $K_x$ and $H(m)$ represent the message digest. Which one of the following indicates the CORRECT way of sending the message $m$ along with the digital signature to A?

(A) $\{m, K_B^+(H(m))\}$
(B) $\{m, K_B^-(H(m))\}$
(C) $\{m, K_A^+(H(m))\}$
(D) $\{m, K_A^-(m)\}$

[Ans. B]
The concept of digital signature
Message is digested: $h(m)$ and cryptographically protected with sender’s private key to become sign and sent along with the message

Q.No. 53
An IP datagram of size 1000 bytes arrives at a router. The router has to forward this packet on a link whose MTU (maximum transmission unit) is 100 bytes. Assume that the size of the IP header is 20 bytes.

The number of fragments that the IP datagram will be divided into for transmission is ________.

[Ans. *] Range: 13 to 13
L = 1000 bytes
MTU = 100 bytes
IP header = 20 bytes
So MTU payload is $100 - 20 = 80$ bytes
Number of fragments = $1000 / 80 = 13$
Q.No. 54
For a host machine that uses the token bucket algorithm for congestion control, the token bucket has a capacity of 1 megabyte and the maximum output rate is 20 megabytes per second. Tokens arrive at a rate to sustain output at a rate of 10 megabytes per second. The token bucket is currently full and the machine needs to send 12 megabytes of data. The minimum time required to transmit the data is _________ seconds.

[Ans. *] Range: 1.1 to 1.1

Q.No. 55
A sender uses the Stop-and-Wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps (1Kbps = 1000 bits/second). Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 milliseconds. Assuming no frame is lost, the sender throughput is _________ bytes/second.

[Ans. *] Range:2500 to 2500
B = 80 kbps
L = 1000 bytes
T_p = 100 ms
T_x = L/B = 100 ms
Tax = ack size/ bandwidth = 100 ms
Efficiency = tx/(tx +2tp+tax)
Throughput = efficiency × bandwidth = 0.25 × 10^4 bytes
= 2500 bytes