PART I (20 Marks)

Answer all questions.

While answering questions in this Part, indicate briefly your working and reasoning, wherever required.

Question 1

(a) State the law represented by the following proposition and prove it with the help of a truth table: [1]

\[ P \lor P = P \]

(b) State the Principle of Duality. [1]

(c) Find the complement of the following Boolean expression using De Morgan’s law: [1]

\[ F(a,b,c) = (b' + c) + a \]

(d) Draw the logic diagram and truth table for a 2 input XNOR gate. [1]

(e) If \( \neg P \Rightarrow Q \) then write its: [1]

(i) Inverse
(ii) Converse

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Question 2

(a) What is an interface? How is it different from a class?

(b) Convert the following infix expression to postfix form:

\[ P \times Q / R + (S + T) \]

(c) A matrix \( P[15][10] \) is stored with each element requiring 8 bytes of storage. If the base address at \( P[0][0] \) is 1400, determine the address at \( P[10][7] \) when the matrix is stored in **Row Major Wise**.

(d) (i) What is the worst case complexity of the following code segment:

```java
for (int x = 1; x <= a; x++)
{
    statements;
}
for (int y = 1; y <= b; y++)
{
    for (int z = 1; z <= c; z++)
    {
        statements;
    }
}
```

(ii) How would the complexity change if all the three loops went to \( N \) instead of \( a, b \) and \( c \)?

(e) Differentiate between a constructor and a method of a class.

Question 3

The following function \( \text{magicfun}() \) is a part of some class. What will the function \( \text{magicfun}() \) return, when the value of \( n=7 \) and \( n=10 \), respectively? Show the dry run/working:

```java
int magicfun( int n)
{
    if ( n == 0)
        return 0;
    else
        return magicfun(n/2) * 10 + (n % 2);
}
```
PART – II (50 Marks)

Answer six questions in this part, choosing two questions from Section A, two from Section B and two from Section C.

SECTION - A

Answer any two questions.

Question 4
(a) Given the Boolean function $F(A, B, C, D) = \Sigma (2,3,4,5,6,7,8,10,11)$.
   (i) Reduce the above expression by using 4-variable Karnaugh map, showing the various groups (i.e. octal, quads and pairs). [4]
   (ii) Draw the logic gate diagram for the reduced expression. Assume that the variables and their complements are available as inputs. [1]
(b) Given the Boolean function $F(P, Q, R, S) = \pi(0,1,2,4,5,6,8,10)$.
   (i) Reduce the above expression by using 4-variable Karnaugh map, showing the various groups (i.e. octal, quads and pairs). [4]
   (ii) Draw the logic gate diagram for the reduced expression. Assume that the variables and their complements are available as inputs. [1]

Question 5
(a) A school intends to select candidates for an Inter-School Essay Competition as per the criteria given below:
   • The student has participated in an earlier competition and is very creative.
     OR
   • The student is very creative and has excellent general awareness, but has not participated in any competition earlier.
     OR
   • The student has excellent general awareness and has won prize in an inter-house competition.

   The inputs are:

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>participated in a competition earlier</td>
</tr>
<tr>
<td>B</td>
<td>is very creative</td>
</tr>
<tr>
<td>C</td>
<td>won prize in an inter-house competition</td>
</tr>
<tr>
<td>D</td>
<td>has excellent general awareness</td>
</tr>
</tbody>
</table>

(In all the above cases 1 indicates yes and 0 indicates no).

Output: $X$ [1 indicates yes, 0 indicates no for all cases]
Draw the truth table for the inputs and outputs given above and write the POS expression for $X(A,B,C,D)$.
(b) State the application of a **Half Adder**. Draw the truth table and circuit diagram for a Half Adder.

(c) Convert the following Boolean expression into its canonical POS form:
\[ F(A, B, C) = (B + C') \cdot (A' + B) \]

**Question 6**

(a) What is a **Multiplexer**? How is it different from a **decoder**? Draw the circuit diagram for a 8:1 Multiplexer.

(b) Prove the Boolean expression using Boolean laws. Also, mention the law used at each step.
\[ F = (x' + z) + [ (y' + z) \cdot (x' + y) ]' = 1 \]

(c) Define **maxterms** and **minterms**. Find the maxterm and minterm when:
\[ P = 0, Q = 1, R = 1 \text{ and } S = 0 \]

**SECTION – B**

*Answer any two questions.*

Each program should be written in such a way that it clearly depicts the logic of the problem. This can be achieved by using mnemonic names and comments in the program.

(Flowcharts and Algorithms are **not** required.)

The programs must be written in **Java**.

**Question 7**

A class **Palin** has been defined to check whether a positive number is a **Palindrome** number or not.

*The number ‘N’ is palindrome if the original number and its reverse are same.*

Some of the members of the class are given below:

**Class name** : **Palin**

**Data members/instance variables:**
- **num** : integer to store the number
- **revnum** : integer to store the reverse of the number

**Methods/Member functions:**
- **Palin( )** : constructor to initialize data members with legal initial values
- **void accept( )** : to accept the number
- **int reverse(int y)** : reverses the parameterized argument ‘y’ and stores it in ‘revnum’ using recursive technique
- **void check( )** : checks whether the number is a Palindrome by invoking the function reverse( ) and display the result with an appropriate message
Specify the class **Palin** giving the details of the **constructor( )**, **void accept( )**, **int reverse( int )** and **void check( )**. Define the **main( )** function to create an object and call the functions accordingly to enable the task.

**Question 8**

A class **Adder** has been defined to add any two accepted time.  

**Example:**

- Time A - 6 hours 35 minutes  
- Time B - 7 hours 45 minutes  

Their sum is - 14 hours 20 minutes (where 60 minutes = 1 hour)

The details of the members of the class are given below:

<table>
<thead>
<tr>
<th>Class name</th>
<th>Adder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data member/instance variable:</strong></td>
<td></td>
</tr>
<tr>
<td>a[ ]</td>
<td>integer array to hold two elements (hours and minutes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Member functions/methods:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Adder( )</td>
</tr>
<tr>
<td>void readtime( )</td>
</tr>
<tr>
<td>void addtime( Adder X, Adder Y)</td>
</tr>
<tr>
<td>void disptime( )</td>
</tr>
</tbody>
</table>

Specify the class **Adder** giving details of the **constructor( )**, **void readtime( )**, **void addtime(Adder, Adder)** and **void disptime( )**. Define the **main( )** function to create objects and call the functions accordingly to enable the task.
Question 9

A class **SwapSort** has been defined to perform string related operations on a word input. Some of the members of the class are as follows:

<table>
<thead>
<tr>
<th>Class name</th>
<th>:</th>
<th>SwapSort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data members/instance variables:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>wrd</td>
<td>:</td>
<td>to store a word</td>
</tr>
<tr>
<td>len</td>
<td>:</td>
<td>integer to store length of the word</td>
</tr>
<tr>
<td>swapwrd</td>
<td>:</td>
<td>to store the swapped word</td>
</tr>
<tr>
<td>sortwrd</td>
<td>:</td>
<td>to store the sorted word</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Member functions/methods:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SwapSort( )</td>
<td>:</td>
<td>default constructor to initialize data members with legal initial values</td>
</tr>
<tr>
<td>void readword( )</td>
<td>:</td>
<td>to accept a word in UPPER CASE</td>
</tr>
<tr>
<td>void swapchar( )</td>
<td>:</td>
<td>to interchange/swap the first and last characters of the word in ‘wrd’ and stores the new word in ‘swapwrd’</td>
</tr>
<tr>
<td>void sortword( )</td>
<td>:</td>
<td>sorts the characters of the original word in alphabetical order and stores it in ‘sortwrd’</td>
</tr>
<tr>
<td>void display( )</td>
<td>:</td>
<td>displays the original word, swapped word and the sorted word</td>
</tr>
</tbody>
</table>

Specify the class **SwapSort**, giving the details of the constructor( ), void readword( ), void swapchar( ), void sortword( ) and void display( ). Define the main( ) function to create an object and call the functions accordingly to enable the task.

**SECTION – C**

Answer any two questions.

Each program should be written in such a way that it clearly depicts the logic of the problem stepwise.

This can be achieved by using comments in the program and mnemonic names or pseudo codes for algorithms. The programs must be written in Java and the algorithms must be written in general / standard form, wherever required / specified.

(Flowcharts are not required.)

**Question 10**

A super class **Product** has been defined to store the details of a product sold by a wholesaler to a retailer. Define a sub class **Sales** to compute the total amount paid by the retailer with or without fine along with service tax.
Some of the members of both the classes are given below:

**Class name**: Product

**Data member/instance variable**:
- name : stores the name of the product
- code : integer to store the product code
- amount : stores the total sale amount of the product (in decimals)

**Member functions/methods**:
- Product(String n, int c, double p) : parameterized constructor to assign data members name=n, code=c and amount = p
- void show( ) : displays the details of the data members

**Class name**: Sales

**Data member/instance variable**:
- day : stores number of days taken to pay the sale amount
- tax : to store the service tax (in decimals)
- totamt : to store the total amount (in decimals)

**Member functions/methods**:
- Sales(…) : parameterized constructor to assign values to data members of both the classes
- void compute( ) : calculates the service tax @ 12·4% of the actual sale amount
- calculates the fine @ 2·5% of the actual sale amount only if the amount paid by the retailer to the wholesaler exceeds 30 days
- calculates the total amount paid by the retailer as (actual sale amount + service tax + fine)
- void show( ) : displays the data members of super class and the total amount

Assume that the super class Product has been defined. Using the concept of inheritance, specify the class Sales giving the details of the constructor(…), void compute( ) and void show( ).

The super class, main function and algorithm need NOT be written.
**Question 11**

Queue is an entity which can hold a maximum of 100 integers. The queue enables the user to add integers from the rear and remove integers from the front.

Define a class `Queue` with the following details:

<table>
<thead>
<tr>
<th>Class name</th>
<th>Queue</th>
</tr>
</thead>
</table>

**Data Members / instance variables:**

- `Que[ ]`: array to hold the integer elements
- `size`: stores the size of the array
- `front`: to point the index of the front
- `rear`: to point the index of the rear

**Member functions:**

- `Queue (int mm)`: constructor to initialize the data size = mm, front = 0, rear = 0
- `void adddele(int v)`: to add integer from the rear if possible else display the message “Overflow”
- `int delele()`: returns elements from front if present, otherwise displays the message “Underflow” and return -9999
- `void display ( )`: displays the array elements

Specify the class `Queue` giving details of ONLY the functions `void adddele(int)` and `int delele()`. Assume that the other functions have been defined.

**The main function and algorithm need NOT be written.**

**Question 12**

(a) A linked list is formed from the objects of the class `Node`. The class structure of the `Node` is given below:

```java
class Node {
    int num;
    Node next;
}
```

Write an Algorithm OR a Method to count the nodes that contain only odd integers from an existing linked list and returns the count.

The method declaration is as follows:

```java
int CountOdd( Node startPtr )
```
Answer the following questions from the diagram of a Binary Tree given below:

(i) Write the postorder traversal of the above tree structure. [1]
(ii) State the level numbers of the nodes N and R if the root is at 0 (zero) level. [1]
(iii) List the internal nodes of the right sub-tree. [1]