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COMPUTER SCIENCE

Paper – 1
(THEORY)

Three hours

(Candidates are *allowed* additional 15 minutes for only reading the paper.
They must NOT start writing during this time.)

Answer all questions in Part I (compulsory) and seven questions from Part II, choosing three questions from Section-A, two questions from Section-B and two questions from Section-C.

All working, including rough work, should be done on the same sheet as the rest of the answer.

The intended marks for questions or parts of questions are given in brackets [].

PART I

Answer all questions.

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

Question 1

(a) Using a truth table, verify the following expression:

\[ X + (Y + Z) = (X + Y) + Z \]

Also state the law. [2]

(b) Given, \( F(X, Y, Z) = (X' + Y') \cdot (Y + Z') \) write the function in canonical product-of-sum form. [2]

(c) Draw the truth table and logic circuit for a 2-input XNOR gate. [2]

(d) Find the complement of the following expression:

\[ X' + XY' \] [2]

(e) If \( (X \Rightarrow Y) \) then write its:

(i) Converse [2]

(ii) Contra positive

This Paper consists of 10 printed pages.
Question 2

(a) Differentiate between the keywords extends and implements. [2]

(b) State how a binary tree is a recursive data structure. [2]

(c) A matrix B[10][7] is stored in the memory with each element requiring 2 bytes of storage. If the base address at B[x][1] is 1012 and the address at B[7][3] is 1060, determine the value 'x' where the matrix is stored in Column Major wise. [2]

(d) Convert the following infix notation to its postfix form:

\[ A + ( (B+C) + (D+E) * F ) / G \] [2]

(e) What is a constructor? State one difference between a constructor and any other member function of a class. [2]

Question 3

The following function is a part of some class which computes and sorts an array arr[] in ascending order using the bubble sort technique. There are some places in the code marked by \(?1\), \(?2\), \(?3\), \(?4\), \(?5\) which must be replaced by a statement / expression so that the function works properly:

```c
void bubblesort(int arr[ ]) {
    int i, j, k, tmp;
    for(i = 0; \(?1\); i++)
    {
        for(j = 0; \(?2\); j++)
        {
            if(arr[j] > \(?3\))
            {
                tmp = arr[j];
                \(?4\) = arr[j+1];
                arr[j+1] = \(?5\);
            }
        }
    }
}
```

(i) What is the expression or statement at \(?1\)? [1]

(ii) What is the expression or statement at \(?2\)? [1]

(iii) What is the expression or statement at \(?3\)? [1]

(iv) What is the expression or statement at \(?4\)? [1]

(v) What is the expression or statement at \(?5\)? [1]
(b) The following function \texttt{witty()} is a part of some class. What will be the output of the function \texttt{witty()} when the value of \emph{n} is "SCIENCE" and the value of \emph{p} is 5. Show the dry run / working:

```java
void witty(String n, int p)
{
    if (p < 0)
        System.out.println("”);
    else
    {
        System.out.println(n.charAt(p) + " . ");
        witty(n, p-1);
        System.out.print(n.charAt(p));
    }
}
```

PART – II

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

SECTION - A

Answer any three questions.

Question 4

(a) Given the Boolean function: \( F(A,B,C,D) = \Sigma (4, 6, 7, 10, 11, 12, 14, 15) \)

(i) Reduce the above expression by using 4 - variable K-Map, showing the various groups (i.e. octal, quads and pairs). \[4\]

(ii) Draw the logic gate diagram of the reduced expression. Assume that the variables and their complements are available as inputs. \[1\]

(b) Given the Boolean function: \( F(P,Q,R,S) = \pi (0, 5, 7, 8, 10, 12, 13, 14, 15) \)

(i) Reduce the above expression by using 4 - variable K-Map, showing the various groups (i.e. octal, quads and pairs). \[4\]

(ii) Draw the logic gate diagram of the reduced expression. Assume that the variables and their complements are available as inputs. \[1\]
Question 5

The Principal of a school intends to select students for admission to class XI on the following criteria:
- Student is of the same school and has passed the class X Board Examination with more than 60% marks.  
  OR  
- Student is of the same school, has passed the class X Board Examination with less than 60% marks but has taken active part in co-curricular activities.  
  OR  
- Student is not from the same school but has either passed the class X Board Examination with more than 60% marks or has participated in sports at the National level.

The inputs are:

<table>
<thead>
<tr>
<th>INPUTS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Student of the same school</td>
</tr>
<tr>
<td>P</td>
<td>Has passed the class X Board Examination with more than 60% marks</td>
</tr>
<tr>
<td>C</td>
<td>Has taken active part in co-curricular activities.</td>
</tr>
<tr>
<td>T</td>
<td>Has participated in sports at the National level.</td>
</tr>
</tbody>
</table>

Output: X - Denotes admission status [1 indicates granted and 0 indicates refused in all the cases.]

(a) Draw the truth table for the inputs and outputs given above and write the SOP expression.

(b) Reduce X (S, P, C, T) using Karnaugh’s Map.

(c) Draw the logic gate diagram for the reduced SOP expression for X (S, P, C, T) using AND and OR gate. You may use gates with two or more inputs. Assume that the variable and their complements are available as inputs.

Question 6

(a) Verify algebraically if:

\[ X'Y'Z' + X'Y'Z + X'YZ + X'YZ' + XY'Z' + XY'Z = X' + Y' \]

(b) Represent the Boolean expression X+YZ' with the help of NOR gates only.

(c) Define the terms Contingency, Contradiction and Tautology.

(d) Consider the following truth table where A and B are two inputs and X is the output:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

(i) Name and draw the logic gate for the given truth table.

(ii) Write the POS of X(A,B).
Question 7

(a) Define Multiplexer and state one of its uses. Draw the logic diagram for a 4:1 Multiplexer.

(b) State how a Half Adder is different from a Full Adder. Also give their respective uses.

(c) Minimize the following expression using Boolean laws:

\[ Q \cdot (Q' + P) \cdot R \cdot (Q + R) \]

Also draw the logic gate for the reduced expression.

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 8

A class Combine contains an array of integers which combines two arrays into a single array including the duplicate elements, if any, and sorts the combined array. Some of the members of the class are given below:

Class name : Combine

Data members / instance variables:

- com[ ] : integer array
- size : size of the array

Member functions/methods:

- Combine (int nn) : parameterized constructor to assign size = nn
- void inputarray( ) : to accept the array elements
- void sort( ) : sorts the elements of combined array in ascending order using the selection sort technique
- void mix(Combine A, Combine B) : combines the parameterized object arrays and stores the result in the current object array along with duplicate elements, if any
- void display( ) : displays the array elements

Specify the class Combine giving details of the constructor( int ), void inputarray( ), void sort( ), void mix(Combine, Combine) and void display( ). Also define the main( ) function to create an object and call the methods accordingly to enable the task.
Question 9

Design a class VowelWord to accept a sentence and calculate the frequency of words that begin with a vowel. The words in the input string are separated by a single blank space and terminated by a full stop. The description of the class is given below:

Class name: VowelWord

Data members / instance variables:

- str: to store a sentence
- freq: store the frequency of the words beginning with a vowel

Member functions:

- VowelWord( ): constructor to initialize data members to legal initial value
- void readstr( ): to accept a sentence
- void freq_vowel( ): counts the frequency of the words that begin with a vowel
- void display( ): to display the original string and the frequency of the words that begin with a vowel

Specify the class VowelWord giving details of the constructor( ), void readstr( ), void freq_vowel( ) and void display( ). Also define the main( ) function to create an object and call the methods accordingly to enable the task.
A happy number is a number in which the eventual sum of the square of the digits of the number is equal to 1.

Example: \[28 = (2)^2 + (8)^2 = 4 + 64 = 68\]
\[68 = (6)^2 + (8)^2 = 36 + 64 = 100\]
\[100 = (1)^2 + (0)^2 + (0)^2 = 1 + 0 + 0 = 1\]

Hence, 28 is a happy number.

Example: \[12 = (1)^2 + (2)^2 = 1 + 4 = 5\]

Hence, 12 is not a happy number.

Design a class Happy to check if a given number is a happy number. Some of the members of the class are given below:

**Class name**: Happy

**Data members/instance variables**: stores the number

**Member functions**:

- **Happy()**: constructor to assign 0 to n
- **void getnum(int nn)**: to assign the parameter value to the number n = nn
- **int sum_sq_digits(int x)**: returns the sum of the square of the digits of the number x, using the recursive technique
- **void ishappy()**: checks if the given number is a happy number by calling the function sum_sq_digits(int) and displays an appropriate message

Specify the class Happy giving details of the constructor( ), void getnum(int), int sum_sq_digits(int) and void ishappy( ). Also define a main( ) function to create an object and call the methods to check for happy number.
SECTION – C

Answer any two questions.

Each Program / Algorithm should be written in such a way that it clearly depicts the logic of the problem step wise. This can also be achieved by using pseudo codes.

(Flowcharts are not required).

The programs must be written in Java.

The Algorithm must be written in general/standard form, wherever required.

Question 11

Link is an entity which can hold a maximum of 100 integers. Link enables the user to add elements from the rear end and remove integers from the front end of the entity.

Define a class Link with the following details:

Class name : Link

Data members/instant variables:

- \text{lnk}[]
- \text{max}
- \text{begin}
- \text{end}

Member functions:

- \text{Link(int mm)}
- \text{void addlink(int v)}
- \text{int dellink()}
- \text{void display( )}

(a) Specify the class Link giving details of the \textbf{constructor(int)}, \textbf{void addlink(int)}, \textbf{int dellink()} and \textbf{void display( )}. [9]

THE MAIN FUNCTION AND ALGORITHM NEED NOT BE WRITTEN.

(b) What type of data structure is the above entity? [1]
Question 12

A super class `Detail` has been defined to store the details of a customer. Define a sub class `Bill` to compute the monthly telephone charge of the customer as per the chart given below:

<table>
<thead>
<tr>
<th>NUMBER OF CALLS</th>
<th>RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – 100</td>
<td>Only rental charge</td>
</tr>
<tr>
<td>101 – 200</td>
<td>60 paisa per call + rental charge</td>
</tr>
<tr>
<td>201 – 300</td>
<td>80 paisa per call + rental charge</td>
</tr>
<tr>
<td>Above 300</td>
<td>1 rupee per call + rental charge</td>
</tr>
</tbody>
</table>

The details of both the classes are given below:

**Class name**

**Data members / instance variables:**

- `name`
- `address`
- `telno`
- `rent`

**Member functions:**

- `Detail(...)`
- `void show( )`

**Class name**

**Data members / instance variables:**

- `n`
- `amt`

**Member functions:**

- `Bill(...)`
- `void cal( )`
- `void show( )`

Specify the class `Detail` giving details of the `constructor( )` and `void show( )`. Using the concept of inheritance, specify the class `Bill` giving details of the `constructor( )`, `void cal( )` and `void show( )`. 

THE MAIN( ) FUNCTION AND ALGORITHM NEED NOT BE WRITTEN.
Question 13

(a) A linked list is formed from the objects of the class, class node
{
    int p;
    String n;
    node next;
}

Write an Algorithm OR a Method to search for a name and display the contents of that node. The method declaration is given below:

    void search( node start, String b )

(b) What is the role of constants in complexity? Explain briefly with an example.

(c) Answer the following from the diagram of a Binary Tree given below:

(i) External nodes of the tree.
(ii) Parent of node D.
(iii) Inorder traversal of the tree.
(iv) Right subtree of Node B.

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