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ISC COMPUTER SCIENCE

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SOLUTION PAPER

Question 1

(i) According to the *Principle of duality*, the Boolean equation $(A + B') \cdot (A + 1) = A + B'$ will be equivalent to:

(a) $(A' + B) \cdot (A' + 1) = A' + B$

(b) $(A \cdot B') + (A \cdot 0) = A \cdot B'$

(c) $(A' \cdot B) + (A' \cdot 1) = A' \cdot B$

(d) $(A' \cdot B) + (A' \cdot 0) = A' \cdot B$

Answer: (b) (A.B') + (A.0) = A.B'

Explanation: The principle of duality states that AND changed to OR and vice versa, 0 changed to and vice versa but the complement doesn't change.

(ii) When a sequence of OR, NOT, NOR are connected in series, the logic gate obtained is:

(a) AND

(b) NOT

(c) OR

(d) XOR

Answer: (c) OR

Explanation: OR passed through NOT = NOR, NOR passed through NOR = OR

(iii) Idempotence Law states that:

(a) $X + X = X$

(b) $X + X' = 0$

(c) $X + X = 1$

(d) $X + X' = X$

Solution: (a) X + X = X

Explanation: Idempotence law states that X.X = X and X+X=X

(iv) **Assertion:** For proposition $\sim A \Rightarrow B$, its contrapositive is $B \Rightarrow \sim A$

Reason: Contrapositive is the converse of inverse for any proposition.

(a) Both Assertion and Reason are true, and Reason is the correct explanation for the Assertion.

(b) Both Assertion and Reason are true, but Reason is not the correct explanation for the Assertion.

(c) Assertion is true but Reason is false.

(d) Assertion is false but Reason is true.

Answer: (a) Both Assertion and Reason are true, and Reason is the correct explanation for the Assertion.

Explanation: Inverse of $A \rightarrow B = \sim A \rightarrow \sim B$

Converse is $B \rightarrow A$

Contrapositive is $\sim B \rightarrow \sim A$ i.e. it is converse of inverse or inverse of converse.

(v) The complement of the Boolean expression $(P' \bullet Q) + (R \bullet S')$ is:

(a) $(P' + Q) \bullet (R' + S)$

(b) $(P + Q') \bullet (R' + S)$

(c) $(P' + Q) \bullet (R + S')$

(d) $(P + Q') \bullet (R + S')$

Answer: (b) (P+Q') . (R'+S)

Explanation: ((P'.Q) + (R.S'))' = (P'.Q)' . (R+S')' = (P+Q') . (R'+S)

(vi) **Assertion:** Recursive data structure follows the **LIFO** principle.

Reason: Execution of recursive code follows the concepts of data structure **Queue.**

(a) Both Assertion and Reason are true, and Reason is the correct explanation for the Assertion.

(b) Both Assertion and Reason are true, but Reason is not the correct explanation for the Assertion.

(c) Assertion is true but Reason is false.

(d) Assertion is false but Reason is true.

Answer: (c) Assertion is true but Reason is false.

Explanation: LIFO principle is followed in Stack whereas FIFO principle is followed in Queue.

(vii) State *any one* use of *interfaces* in Java.

(viii) Write the cardinal form of the maxterm X + Y' + Z

(ix) Write the *canonical* SOP expression for F (A, B) = A <=> B

(x) State *any one* difference between **instance variable and class variable.**

Answer:

(vii) Interface is used to implement multiple inheritance in Java.

(viii) Cardinal form of (X + Y'+ Z) $= (010)_2 = 2$

(ix) F(A,B) = A.B + A'.B'

(x) 1. An instance variable is created for each object separately whereas class variables are created only once and every object of the class shares them.

2. An instance variable is declared without the **static** keyword whereas a class variable is created with the **static** keyword in a class.

Question 2

(i) Convert the following infix notation to postfix form.

(P + Q * R – S) / T * U

(ii) An array ARR [–5 .....15, 10.....20] stores elements in **Row Major Wise** with each element requiring 2 bytes of storage. Find the address of ARR [10] [15] when the base address is 2500.

(i) (P + Q * R – S) / T * U

= (P + QR* - S) / TU*

= (P + QR*S-) /TU*

= (PQR*S - +) / TU*

= PQR*S - + TU*/

Order of precedence :

( )	
***, /, %**	Same precedence, but the order of operation is left to right
+, -	Same precedence, but the order of operation is right to left

(ii) Row Major Wise Formula: **$A = B + W * ((I - I_0) * C + (J - J_0))$**

B = 2500, W= 2, C = 20-10+1 = 11, I,J = 10,15 and I_0, J_0 = -5,10

A= 2500 + 2 * ((10-(-5))*11 + (15-10))

2500 + 2 * (15*11+5)

2500 + 2*170

2500 + 340

2840

(iii) The following function is a part of some class:

```
int jolly(int[ ] x, int n, int m)
 {
  if (n < 0)
          return m;
  else if(n<x.length)
          m = (x[n] > m)? x[n] : m;
  return jolly(x, --n, m);
  }
```

(a) What will be the output of **jolly( )** when the value of **x[ ]={6,3,4,7,1}** , **n=4** and **m=0**?

(b) What function does **jolly( )** perform, apart from recursion?

Answer: (iii)

(a)7

Working:

jolly({6,3,4,7,1}, 4, 0) // X.length = 5, n=4, m=0

m = 1

jolly({6,3,4,7,1}, 3, 0)

m = 7

jolly({6,3,4,7,1}, 2, 0)

m = 7

jolly({6,3,4,7,1}, 1, 0)

m = 7

jolly({6,3,4,7,1}, 0, 0)

m = 7

(b) Returning the largest no. of the array X[]

(iv) The following function is a part of some class which is used to find the smallest digit present in a number. There are some places in the code marked by **?1?**, **?2?**, **?3?** which must be replaced by an expression / a statement so that the function works correctly.

```
int small_dig(int n)
{   int min = ?1? ;
      while (n != 0)
      {
         int q=n/10;
         int r = ?2? * 10;
         min = r > min ?  ?3?  : r;
         n=q;
       }
      return min;
}
```

(a) What is the expression or statement at **?1?**

(b) What is the expression or statement at **?2?**

(c) What is the expression or statement at **?3?**

Answer: (iv)

(a) n

(b) n%10 + 0

(c) min

```
int small_dig(int n)
{
   int min=n;
   while(n!=0)
   {
      int q=n/10;
      int r=n%10 + 0*10;
      min=r>min?min:r;
      n=q;
   }
   return(min);
}
```

Question 3

(i) To be recruited as the Principal in a renowned College, a candidate must satisfy any one of the following criteria: [5]

- The candidate must be a Postgraduate and should either possess a B.Ed. degree or a teaching experience of more than 15 years.

OR

- The candidate must be an employee of the same college with a teaching experience of more than 15 years.

OR

- The candidate must be a Postgraduate but not an employee of the same college and should have a teaching experience of more than 15 years.

The inputs are:

INPUTS	
P	Candidate is a Postgraduate
S	Candidate is an employee of the same College
E	Candidate has a teaching experience of more than 15 years
B	Candidate possesses a B.Ed. degree

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

Output: **X** - Denotes eligibility of a candidate [1 indicates eligibility and 0 indicates ineligibility in all cases]

Draw the truth table for the inputs and outputs given above and write the **SOP** expression for **X (P, S, E, B)**.

P	S	E	B	X	Minterm
0	0	0	0		
0	0	0	1		
0	0	1	0		
0	0	1	1		
0	1	0	0		
0	1	0	1		
0	1	1	0	**1**	P’.S.E.B’
0	1	1	1	**1**	P’.S.E.B
1	0	0	0		
1	0	0	1	**1**	P.S’.E’.B
1	0	1	0	**1**	P.S’.E.B’
1	0	1	1	**1**	P.S’.E.B
1	1	0	0		
1	1	0	1	**1**	P.S.E’.B
1	1	1	0	**1**	P.S.E.B’
1	1	1	1	**1**	P.S.E.B

(i) X(P, S, E, B) = P’.S.E.B’ + P’.S.E.B + P.S’.E’.B + P.S’.E.B’ + P.S’.E.B + P.S.E’.B + P.S.E.B’ + P.S.E.B

= Σ (6,7,9,10,11,13,14,15)

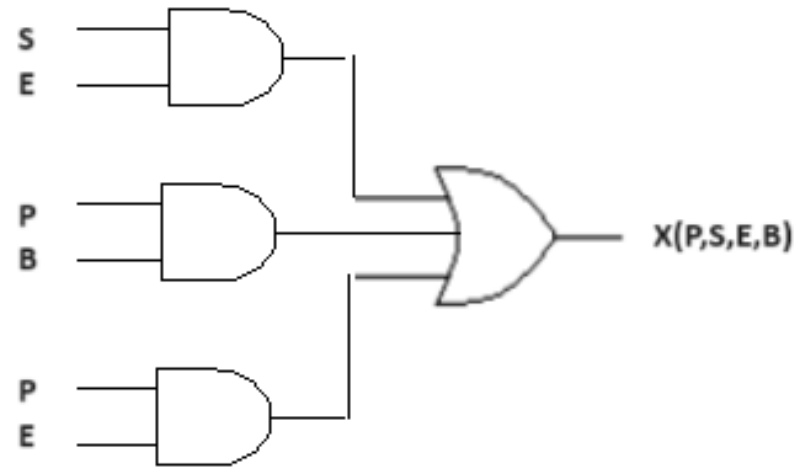
(ii) Reduce the above expression **X (P, S, E, B)** by using 4-variable Karnaugh map, showing the various groups (i.e., octal, quads and pairs).
Draw the logic gate diagram for the reduced expression. Assume that the variables and their complements are available as inputs.

K-Map

PS\EB	E'.B'	E'.B	E.B	E.B'
P'.S'				
P'.S			1	1
P.S		1	1	1
P.S'		1	1	1

Quad 1 (m7,m6,m15,m14) = S.E
Quad 2 (m13,m15,m9,m11) = P.B
Quad 3 (m15,m14,m11,m10) = P.E
X(P,S,E,B) = S.E + P.B + P.E

Logic gate



Question 4

(i) (a) Reduce the Boolean function **F (A,B,C,D) = π (0, 2, 4, 6, 8, 9, 10, 11, 14)** by using 4-variable Karnaugh map, showing the various groups (i.e., octal, quads and pairs).

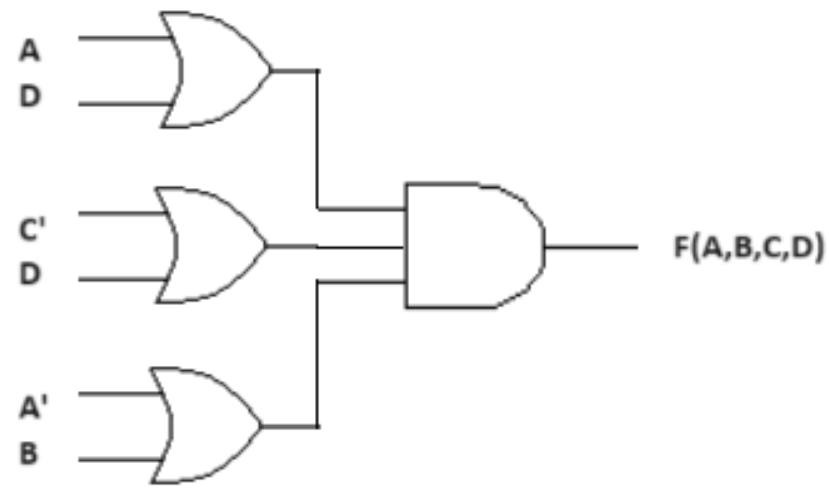
(b) Draw the logic gate diagram for the reduced expression. Assume that the variables and their complements are available as inputs.

(a) F(A,B,C,D) = π (0,2,4,6,8,9,10,11,14)

K-Map

AB\CD	C+D	C+D'	C'+D'	C'+D
A+B	0			0
A+B'	0			0
A'+B'				0
A'+B	0	0	0	0

Quad 1 (m0,m2,m4,m6) = A+D
Quad 2 (m2,m4,m14,m10) = C'+D
Quad 3 (m8,m9,m11,m10) = A'+B
F(A,B,C,D) = (A+D) . (C'+D) . (A'+B)



(ii) Verify if the following proposition is a Tautology, Contradiction or a Contingency, using a truth table.

$$((A \Rightarrow B) \wedge (B \Rightarrow C)) \Rightarrow (A \Rightarrow C)$$

(iii) Find the complement of the following expression and reduce it by using Boolean laws.

$$P \cdot (P + Q) \cdot Q \cdot (Q + R')$$

A	B	C	A→B	B→C	(A→B) ^ (B→C)	A→C	((A→B) ^ (B→C)) → (A→C)
0	0	0	1	1	1	1	1
0	0	1	1	1	1	1	1
0	1	0	1	0	0	1	0
0	1	1	1	1	1	1	1
1	0	0	0	1	0	0	1
1	0	1	0	1	0	1	0
1	1	0	1	0	0	0	1
1	1	1	1	1	1	1	1

(ii) **It is a Contingency**

(iii) Complement: (P . (P+Q) . Q . (Q+R'))'

P' + (P+Q)' + Q' + (Q+R')' by applying De Morgan's law

P' + P'.Q' + Q' + Q'.R

If we further simplify:

P' (1+Q') + Q' (1+R') = P'+Q'

Question 5

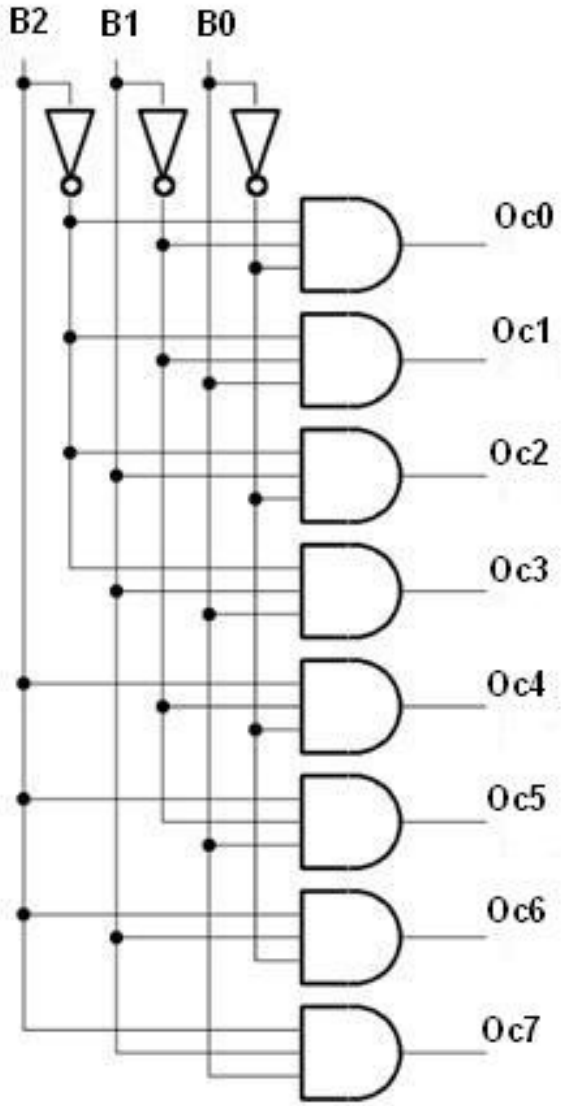
(i) How is a *decoder* different from a *multiplexer*? Draw the logic circuit for 3:8 decoder (Octal decoder). Which multiplexer can be derived from the Octal decoder?

(ii) Draw the logic gate diagram for 2-input OR gate using NAND gates only. Show the expression at each step.

(iii) Write the *canonical* form of the cardinal terms, m_3 and M_5 for F (A, B, C, D).

Multiplexer	Decoder
Multiplexer has n data input lines and one output line.	Decoder has no data input and there is n output line.
There are m control lines.	Inputs are the control bits A, B, C, D.
Depending upon the status of the control line, data on the particular input line is available at the output.	Only one output is high which depends on the status of the control lines.
Converts the unary code to binary code	Converts binary code into unary.

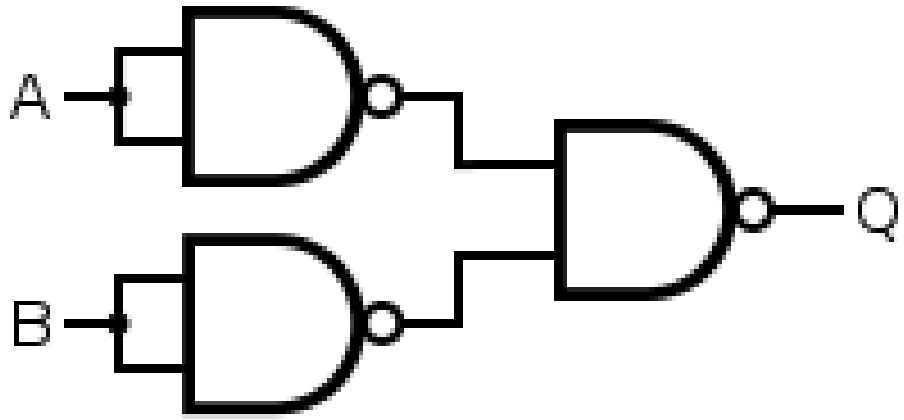
3:8 Decoder circuit



Since, an Octal decoder is 3-to-8 decoder circuit and $(2)^3 = 8$, the said multiplexer will have 8 input lines, 3 select lines and 1 output line. Thus, it will be **8:1 Multiplexer.**

(ii)

2-input OR gate using NAND gate:



Working:

Q = $A \cdot B$

= $(A)'+(B)'$ (By De Morgan's Law)

= A+B (By Involution Rule)

(iii)

M_3 for F(A,B,C,D) = $(0011)_2$ = A'.B'.C.D (in minterm)

= A+B+C'+D' (in maxterm)

M_5 for F(A,B,C,D) = $(0101)_2$ = A'.B.C'.D (in minterm)

= A+B'+C+D' (in maxtrem)

Question 6

Design a class **DeciHex** to accept a positive integer in decimal number system from the user and display its hexadecimal equivalent.

Example 1: Decimal number = 25 Hexadecimal equivalent = 19
Example 2: Decimal number = 28 Hexadecimal equivalent = 1C

Some of the members of the class are given below.

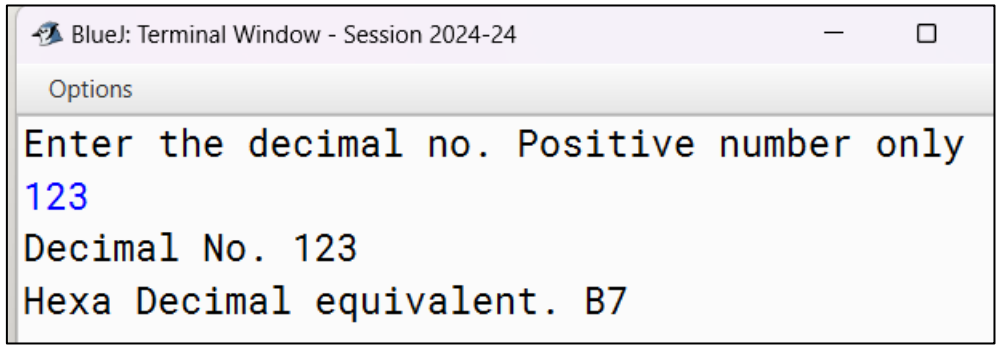
Class name	:	**DeciHex**
Data members/instance variables:		
num	:	stores the positive integer
hexa	:	string to store the hexadecimal equivalent of num
Methods / Member functions:		
DeciHex( )	:	constructor to initialise the data members with legal initial values
void getNum( )	:	to accept a positive integer
void convert(int n)	:	to find the hexadecimal equivalent of the formal parameter 'n' using the **recursive technique**
void display( )	:	to display the decimal number and its hexadecimal equivalent by invoking the function convert( )

Specify the class **DeciHex** giving details of the **constructor( ), void getNum( ), void convert(int) and void display( )**. Define a **main( )** function to create an object and call all the functions accordingly to enable the task.

```
import java.util.Scanner;
class DeciHex
{
   int num;
   String hexa;

   public DeciHex()
   {
      num=0;
      hexa="";
   }

   public void getNum()
   {
      Scanner sc=new Scanner(System.in);
      System.out.println("Enter the decimal no. Positive number only");
      num=Math.abs(sc.nextInt());
   }
```

```
public void convert(int n)
  {
     if(n==0)
     return;
     else
     {
        int a=n%16;
        if(a>=0&&a<=9)
        hexa+=""+a;
        else
        {
           switch(a)
           {
           case 10:hexa+='A'; break;
           case 11:hexa+='B'; break;
           case 12:hexa+='C'; break;
           case 13:hexa+='D'; break;
           case 14:hexa+='E'; break;
           case 15:hexa+='F'; break;
           }
        }
        convert(n/16);
     }
  }
```

```
 public void display()
    {
       convert(num);
       System.out.println("Decimal No. "+num);
       System.out.println("Hexa Decimal equivalent. "+hexa);
    }

    public static void main(String ar[])
    {
       DeciHex ob=new DeciHex();
       ob.getNum();
       ob.display();
    }
}
```



Question 7 [1(

A class **InsSort** contains an array of integers which sorts the elements in a particular order.

Some of the members of the class are given below.

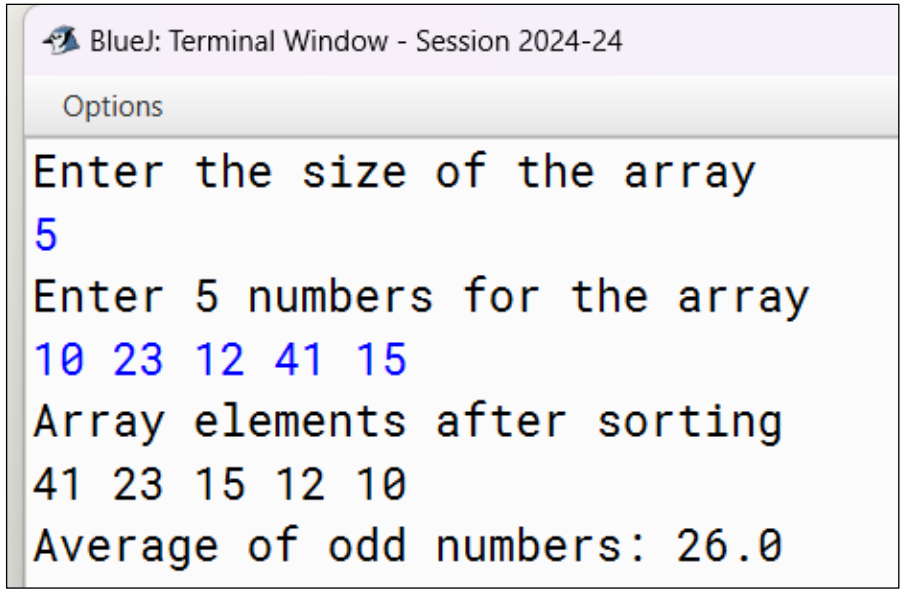
Class name	:	**InsSort**
Data members/instance variables:		
arr[ ]	:	stores the array elements
size	:	stores the number of elements in the array
Methods / Member functions:		
InsSort(int s)	:	constructor to initialise size = s
void getArray( )	:	accepts the array elements
void insertionSort( )	:	sorts the elements of the array in descending order using the **Insertion Sort technique**
double find( )	:	calculates and returns the average of all the odd numbers in the array
void display( )	:	displays the elements of the array in a sorted order along with the average of all the odd numbers in the array by invoking the function find( ) with an appropriate message

Specify the class **InsSort** giving details of the **constructor( ), void getArray( ), void insertionSort( ), double find( ) and void display( )**. Define a **main( )** function to create an object and call all the functions accordingly to enable the task.

```
import java.util.Scanner;
class InsSort
{
    int arr[];
    int size;

    public InsSort(int s)
    {
        size=Math.abs(s);
        arr=new int[size];
    }

    public void getArray()
    {
        Scanner sc=new Scanner(System.in);
        System.out.println("Enter "+size+" numbers for the array");
        for(int i=0;i<size;i++)
            arr[i]=sc.nextInt();
    }
```

```
public void insertionSort()
{
    for(int i=1;i<size;i++)
    {
        int b=arr[i], j=i-1;
        while(j>=0 && arr[j]<b)
        {
            arr[j+1]=arr[j]; j--;
        }
        arr[j+1]=b;
    }
}
public double find()
{
    int odd=0,c=0;
    for(int i=0;i<size;i++)
    {
        if(arr[i]%2!=0)
        {
            odd+=arr[i];  c++;
        }
    }
    return (odd/c);
}
```

```
public void display()
    {
        insertionSort();
        System.out.println("Array elements after sorting");
        for(int i=0;i<size;i++)
        System.out.print(arr[i]+" ");
        System.out.println("\nAverage of odd numbers: "+find());
    }

    public static void main(String args[])
    {
        Scanner ins=new Scanner(System.in);
        System.out.println("Enter the size of the array");
        int a=ins.nextInt();
        InsSort obi=new InsSort(a);
        obi.getArray();
        obi.display();
    }
}
```



Question 8

Design a class **Coding** to perform some string related operations on a word containing alphabets only.

Example: Input: "Java"
Output: Original word: Java
J = 74
a = 97
v = 118
a = 97

Lowest ASCII code: 74
Highest ASCII code: 118

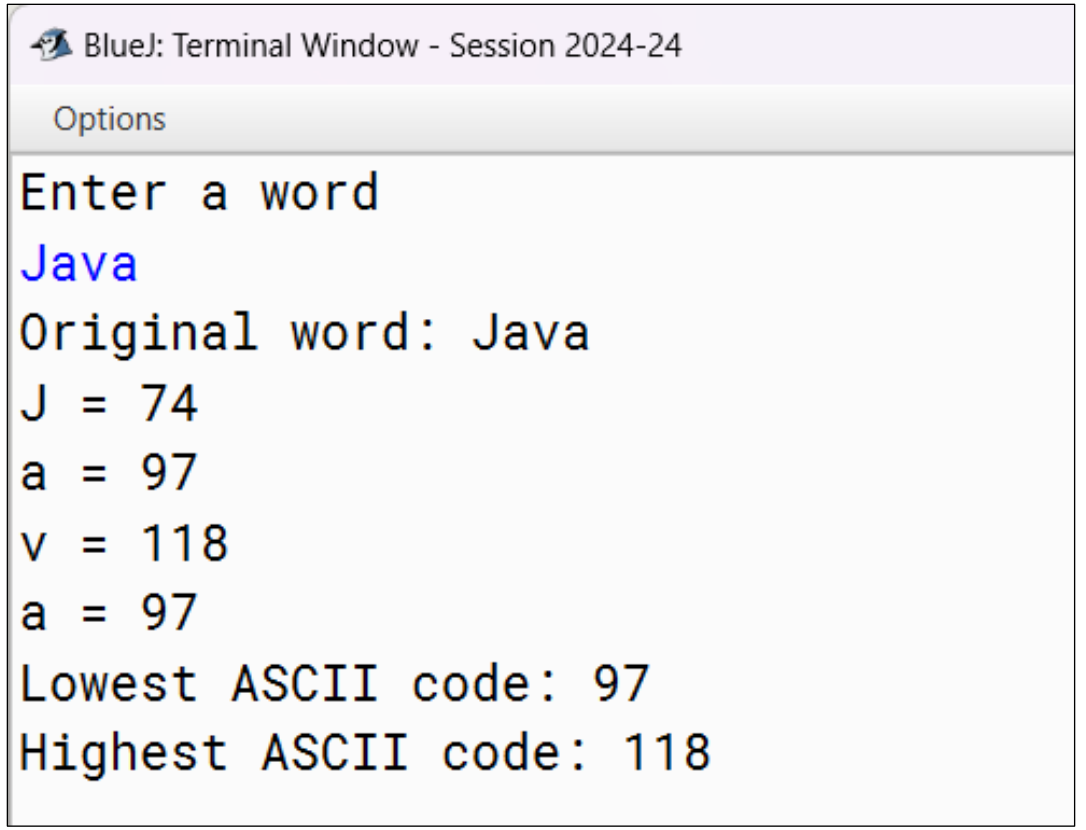
Some of the members of the class are given below.

Class name	:	**Coding**
Data members/instance variables:		
wrd	:	stores the word
len	:	stores the length of the word
Methods / Member functions:		
Coding( )	:	constructor to initialise the data members with legal initial values
void accept( )	:	to accept a word
void find( )	:	to display all the characters of 'wrd' along with their ASCII codes. Also display the lowest ASCII code and the highest ASCII code, in 'wrd'
void show( )	:	to display the original word and all the characters of 'wrd' along with their ASCII codes. Also display the lowest ASCII code and the highest ASCII code in 'wrd', by invoking the function find( )

Specify the class **Coding** giving details of the **constructor( ), void accept( ), void find( )** and **void show( )**. Define a **main( )** function to create an object and call all the functions accordingly to enable the task.

```
import java.util.*;
class Coding
{
    String wrd;
    int len;

    public Coding()
    {
        wrd="";
        len=0;
    }

    public void accept()
    {
        Scanner sc=new Scanner(System.in);
        System.out.println("Enter a word");
        wrd=sc.next().trim();
    }
```

```
public void find()
{     len=wrd.length();
      int small=122,large=65;
      for(int i=0;i<len;i++){
          char ch=wrd.charAt(i);
          if((int)ch>large)
           large=ch;
          else if((int)ch<small)
           small=ch;
          System.out.println(ch+" = "+(int)ch);
      }
      System.out.println("Lowest ASCII code: "+small);
      System.out.println("Highest ASCII code: "+large);
   }
    public void show(){
      System.out.println("Original word: "+wrd);
      find();
   }
    public static void main(String ar[])
      Coding ob=new Coding();
      ob.accept();
      ob.show();
   }
}
```

Question 9

CardGame is a game of mental skill, built on the simple premise of adding and removing the cards from the top of the card pile.

The details of the class **CardGame** are given below.

Class name	:	**CardGame**
Data members/ instance variables:		
cards[ ]	:	array to store integers as cards
cap	:	to store the maximum capacity of array
top	:	to store the index of the topmost element of the array
Methods / Member functions:		
CardGame(int cc)	:	constructor to initialise cap=cc and top= −1
void addCard(int v)	:	to add the card at the top index if possible, otherwise display the message "CARD PILE IS FULL"
int drawCard( )	:	to remove and return the card from the top index of the card pile, if any, else return the value −9999
void display( )	:	to display all the cards of card pile

(i) Specify the class **CardGame** giving details of the functions **void addCard(int)** and **int drawCard( )**. *Assume that the other functions have been defined.*
The main( ) function and algorithm need NOT be written.

(ii) Name the entity described above and state its principle.

```
class CardGame
{
   int cards[];
   int cap,top;

   public CardGame(int cc)
   {
      cap=Math.abs(cc);
      top=-1;
      cards=new int[cap];
   }

   void addCard(int v)
   {
      top++;
      if(top==cap)
      {
         System.out.println("CARD PILE IS FULL");
         top--;
      }
      else
      cards[cap]=v;
   }
```

```
public int drawCard()
   {
      if(top==-1)
      {
         System.out.println("CARD PILE IF EMPTY");
         return -9999;
      }
      else
      return cards[cap--];
   }
   public void display()
   {
       if(top==-1)
          System.out.println("EMPTY CARD PILE");
       else
       {
          for(int i=top; i>=0; i--)
          System.out.println(cards[i]);
       }
   }
}
```

(ii) The above entity is a Stack and its principle is Last In First Out (LIFO)

Question 10 [5]

A super class **EmpSal** has been defined to store the details of an employee. Define a subclass **Overtime** to compute the total salary of the employee, after adding the overtime amount based on the following criteria.

- If hours are more than 40, then ₹ 5000 are added to salary as an overtime amount
- If hours are between 30 and 40 (both inclusive), then ₹ 3000 are added to salary as an overtime amount
- If hours are less than 30, then the salary remains unchanged

The details of the members of both the classes are given below.

Class name	:	**EmpSal**
Data members/instance variables:		
empnum	:	to store the name of the employee
empcode	:	integer to store the employee code
salary	:	to store the salary of the employee in decimal
Methods / Member functions:		
EmpSal(…)	:	parameterised constructor to assign values to data members
void show( )	:	to display the details of the employee
Class name		**Overtime**
Data members/instance variables:		
hours	:	integer to store overtime in hours
totsal	:	to store the total salary in decimal
Methods / Member functions:		
Overtime(…)	:	parameterised constructor to assign values to data members of both the classes
void calSal( )	:	calculates the total salary by adding the overtime amount to salary as per the criteria given above
void show( )	:	to display the employee details along with the total salary (salary + overtime amount)

*Assume that the super class **EmpSal** has been defined.* Using the **concept of inheritance**, specify the class **Overtime** giving the details of the **constructor (...), void calSal( )** and **void show( )**.

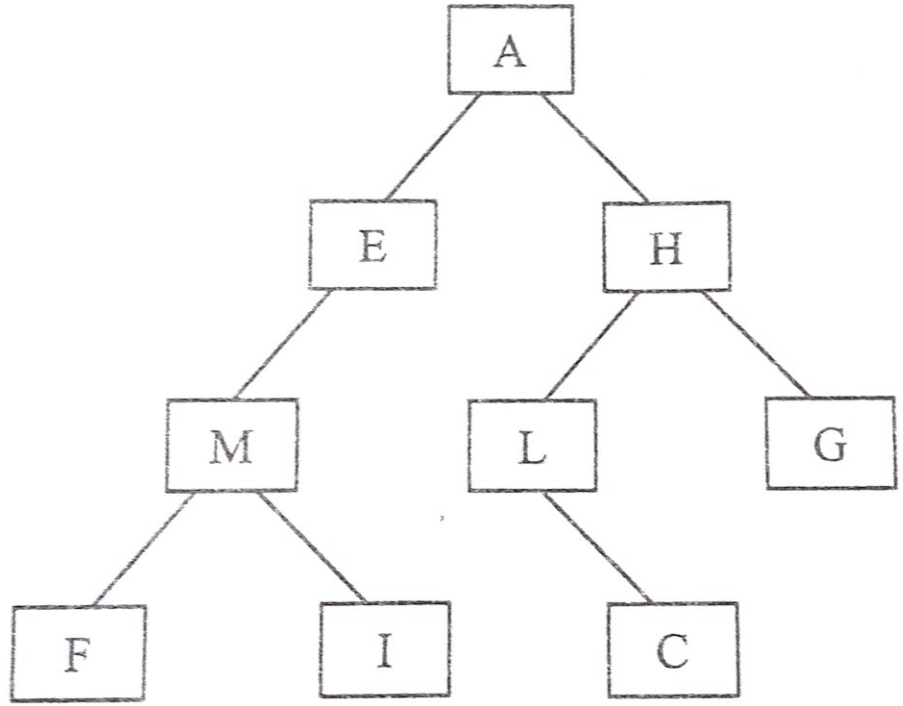
The super class, main function and algorithm need NOT be written.

```
class Overtime extends EmpSal
{
        int hours;
        double totsal;
        public Overtime(String n, int e, double s, int h)
        {
                super(n,e,s);
                hours=h;
        }
        public void calSal( )
        {
                if(hours>40)
                        totsal = salary+5000;
                else if(hours>=30)
                        totsal = salary+3000;
                else
                        totsal = salary;
        }
        public void show( )
        {
                super.show();
                System.out.println("Total salary :"+totsal);
        }
}
```

Question 11

(i) With the help of an example, briefly explain the *dominant term* in complexity.

(ii) Answer the following questions based on the diagram of a Binary Tree given below:



(a) Name the external nodes of the tree.

(b) State the degree of node M and node L.

(c) Write the *post-order* traversal of the above tree structure.

(i) Dominant term: While determining the performance of an algorithm, we have to also consider the term, which plays a vital role and affects the performance of the function. Such a term is known as a dominant term.

For example, let an algorithm have both a nested loop running it N^2 times and a single loop running N times. In this case, N^2 is the dominant term and hence, the complexity is $O(N^2)$.

(ii)

(a) F, I, C, G

(b) Degree of M is 2

Degree of L is 1

(a) F, I, M, E, C, L, G, H, A