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What is Java?

Before we learn about Data Structures using Java, let us understand what Java means.

- Java is a
  - a programming language
  - object-oriented
  - high level
  - originally developed by Sun Microsystems
- It follows the WORA principle
  - stands for “Write Once Run Anywhere”
  - you can run a java program as many times as you want on a java supported platform after it is compiled.

What

- Made u
  - Da
- It is a v
- Example: You might want to store data in
  - Linear fashion – Array/ Linked List
  - One on the other – Stacks
  - Hierarchical Fashion – Trees
  - Connect Nodes – Graph

Do check out our course on Data Structures & Algorithms in Java at Great Learning Academy. In this course, you will start with the concepts of time complexity along with basic algorithms like recursion, searching and sorting. You will also explore various data structures like Arrays, Linked lists, Stacks & Queues, etc. Data structures and algorithms concepts are covered through hands-on coding exercises which ensures practical learning.

List of Data Structures using Java

- Array
- Linked List
- Stack
- Queue
- Binary Tree
- Binary Search Tree
- Heap
- Hashing
- Graph

Also Read: Data Structures using C

Arrays

- Linear Data Structure
- Elements are stored in contiguous memory locations
- Can access elements randomly using index
- Stores homogeneous elements i.e, similar elements
- Syntax:
- Array declaration
  - datatype varname []=new datatype[size];
  - datatype[] varname=new datatype[size];

- Can also do declaration and initialization at once
  - Datatype varname [] = {ele1, ele2, ele3, ele4};

Advantages

- Random access
- Easy sorting and iteration
- Replacement of multiple variables

Disadvantages

- Size is
- Differ
- If capa
- Needs

Applications

- For storing information in a linear fashion
- Suitable for applications that require frequent searching

Demonstration of Array

```
import java.util.*;

class JavaDemo {
    public static void main (String[] args) {
        int[] priceOfPen= new int[5];
        Scanner in=new Scanner(System.in);
        for(int i=0;i<priceOfPen.length;i++)
            priceOfPen[i]=in.nextInt();

        for(int i=0;i<priceOfPen.length;i++)
            System.out.print(priceOfPen[i]+" ");
    }
}
```

Input:

23 13 56 78 10

Output:

23 13 56 78 10

Also Read: How to choose the right programming language for Data Science?

Linked List

- Linear Data Structure
- Elements can be stored as per memory availability
- Can access elements on linear fashion only
- Stores homogeneous elements i.e, similar elements
- Dynamic in size
- Easy insertion and deletion
- Starting element or Node is the key which is generally termed as head.

Advantages

- Dynam
- No wa
- Easy ir
- Efficic

Disadvantages

- If head Node is lost, the linked list is lost
- No random access possible

Applications

- Suitable where memory is limited
- Suitable for applications that require frequent insertion and deletion

Demonstration of Linked List

```
import java.util.*;

class LLNode{

	int data;
	LLNode next;

	LLNode(int data)
	{
		this.data=data;
		this.next=null;

	}
}


class Demo{

	LLNode head;


	LLNode insertInBeg(int key,LLNode head)
	{
		LLNode ttmp=new LLNode(key);

		if(head==null)
			head=ttmp;
```

```
        return head;
    }


    LLNode insertInEnd(int key,LLNode head)
    {
        LLNode ttmp=new LLNode(key);
        LLNode ttmp1=head;

        if(ttmp1==null)
            head=ttmp;
        else
        {
            while(ttmp1.next!=null)
                    ttmp1=ttmp1.next;
            ttmp1.next=ttmp;

        }

        return head;

    }


    LLNode insertAtPos(int key,int pos,LLNode head)
    {
        LLNode ttmp=new LLNode(key);

        if(pos==1)
        {
            ttmp.next=head;
            head=ttmp;
        }
        else
        {
            LLNode ttmp1=head;
            for(int i=1;ttmp1!=null && i<pos;i++)
                ttmp1=ttmp1.next;
```

```
        return head;
    }


    LLNode delete(int pos,LLNode head)
    {
        LLNode ttmp=head;
        if(pos==1)
            head=ttmp.next;
        else
        {
            for(int i=1;ttmp!=null && i<pos-1;i++)
                ttmp=ttmp.next;
            ttmp.next=ttmp.next.next;
        }
        return head;
    }

    int length(LLNode head)
    {
        LLNode ttmp=head;
        int c=0;
        if(ttmp==null)
            return 0;
        else
        {
         while(ttmp!=null)
            {   ttmp=ttmp.next;
                c++;
            }
        }
        return c;
    }


    LLNode reverse(LLNode head)
    {
        LLNode prevLNode=null,curLNode=head,nextLNode=null;
        while(curLNode!=null)
```

```
            prevLNode=curLNode;
            curLNode=nextLNode;
        }

        head=prevLNode;
        return head;
    }


    void display(LLNode head)
    {
        LLNode ttmp=head;
        while(ttmp!=null)
            {System.out.print(ttmp.data+" ");
             ttmp=ttmp.next;
            }
    }

    public static void main(String[] args)
    {
        LinkedListDemo l=new LinkedListDemo();
        l.head=null;
        Scanner in=new Scanner(System.in);
         do
    {
System.out.println("\n********* MENU *********");
        System.out.println("\n1.Insert In End");
        System.out.println("\n2.Insert In Beg");
        System.out.println("\n3.Insert At A  Particular Pos");
        System.out.println("\n4.Delete At a Pos");
        System.out.println("\n5.Length");
        System.out.println("\n6.Reverse");
        System.out.println("\n7.Display");
        System.out.println("\n8.EXIT");
        System.out.println("\nenter ur choice : ");
        int n=in.nextInt();
        switch(n)
            {case 1: System.out.println("\nenter the value ");
                l.head=l.insertInEnd(in.nextInt(),l.head);
```

```
            case 3: System.out.println("\nEnter the value");
                    l.head=l.insertAtPos(in.nextInt(),in.nextInt(),l.head);
                    break;
            case 4:
                    l.head=l.delete(in.nextInt(),l.head);
                    break;
            case 5:
                   System.out.println(l.length(l.head));
                    break;
            case 6:
                    l.head=l.reverse(l.head);
                    break;
            case 7:
                  l.display(l.head);
                        break;
            case 8: System.exit(0);
                        break;
            default: System.out.println("\n Wrong Choice!");
                         break;
                }
         System.out.println("\n do u want to cont... ");
        }while(in.nextInt()==1);

 }
}
```

Output:

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :

1

enter the value

23

do u want to cont...

1

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :

1

enter the value

56

do u wa
1
******* MENU

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :
2

enter the value
10

do u want to cont...
1

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Revers

7.Displa

8.EXIT

enter ur choice :

7

10 23 56

do u want to cont...

1

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :

3

enter the value

67

2

do u want to cont...

1

********* MENU *********

1.Insert In End

2.Insert .

3.Insert .

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :

7

10 23 67 56

do u want to cont...

1

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :

4

2

do u wa
1

****

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :
7
10 67 56
do u want to cont...
1

******** MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur
6

do u want to cont...
1

********* MENU *********

1.Insert In End

2.Insert In Beg

3.Insert At A Particular Pos

4.Delete At a Pos

5.Length

6.Reverse

7.Display

8.EXIT

enter ur choice :
7
56 67 10
do u want to cont...

Stack

- Linear
- Follow
- Only tl
- Insertic
- Eg: a s
- 4 majo
  - push(ele) – used to insert element at top
  - pop() – removes the top element from stack
  - isEmpty() – returns true is stack is empty
  - peek() – to get the top element of the stack
- All operation works in constant time i.e, O(1)

Advantages

- Maintains data in a LIFO manner
- The last element is readily available for use
- All operations are of O(1) complexity

Disadvantages

- Manipulation is restricted to the top of the stack
- Not much flexible

Applications

- Recursion
- Parsing
- Browser
- Editors

Demonstration of Stack – using Array

```
import java.util.*;

class Stack
{
  int[] a;
  int top;
  Stack()
  {
      a=new int[100];
      top=-1;
  }

  void push(int x)
  {
      if(top==a.length-1)
        System.out.println("overflow");
      else
```

```
        a[+
    }
    int pop
    {
      if(top==-1)
            {System.out.println("underflow");
          return -1;
            }
       else
        return(a[top--]);
      }

      void display()
      {
            for(int i=0;i<=top;i++)
                  System.out.print(a[i]+" ");
            System.out.println();
      }

      boolean isEmpty()
      {
            if(top==-1)
                  return true;
            else
                  return false;
      }

      int peek()
      {
            if(top==-1)
                  return -1;
            return (a[top]);
      }


}

public class Demo
{
      public static void main(String args[])
      {
```

```
{System.out.println("\t                MENU");
System.out.println("\n1.PUSH");
System.out.println("\n2.POP");
System.out.println("\n3.PEEK");
System.out.println("\n4 IS EMPTY");
System.out.println("\n5.EXIT");
System.out.println("\n enter ur choice : ");
switch(in.nextInt())
    {
    case 1:
        System.out.println("\nenter the value ");
        s.push(in.nextInt());
        break;
    case 2:
       System.out.println("\n popped element : "+ s.pop());
        break;

   case 3:
       System.out.println("\n top element : "+ s.peek());
        break;
    case 4: System.out.println("\n is empty : "+ s.isEmpty());
            break;
    case 5: System.exit(0);
            break;
    default: System.out.println("\n Wrong Choice!");
             break;
    }
System.out.println("\n do u want to cont... ");
}while(in.nextInt()==1);

  }
}
```

Output:

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5.EXIT

enter ur choice :
1

enter the value
12

do u want to cont...
1

******** MENU *******

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5.EXIT

enter ur choice :
1

enter the value
56

do u want to cont...
1

****

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5.EXIT

enter ur choice :
2

popped element : 56

do u want to cont...
1

******** MENU *******

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5.EXIT

enter ur choice :
4

is empty : false

do u want to cont...
1

******** MENU *******

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5.EXIT

enter ur choice :
2

popped element : 12

do u want to cont...

Demonstration of Stack – using LinkedList

```
import java.util.*;

class LNode
{
	int data;
	LNode next;
	LNode(int d)
	{
		data=d;
	}

}

class Stack
{
	LNode push(int d,LNode head){

			LNode tmp1 = new LNode(d);

			if(head==null)

				head=tmp1;

			else
			{
```

```
                return head;
            }


    LNode pop(LNode head){

        if(head==null)
            System.out.println("underflow");
        else
                head=head.next;
            return head;
        }


    void display(LNode head){

                System.out.println("\n list is : ");
                if(head==null){

                    System.out.println("no LNodes");

                    return;
                    }

                LNode tmp=head;

                while(tmp!=null){

                System.out.print(tmp.data+" ");

                tmp=tmp.next;


                }
        }

  boolean isEmpty(LNode head)
    {
        if(head==null)
```

```
    }

    int peek(LNode head)
    {
        if(head==null)
            return -1;
        return head.data;
    }

}


public class Demo{

        public static void main(String[] args)
        {
        Stack s=new Stack();
        LNode head=null;
        Scanner in=new Scanner(System.in);

         do
            {System.out.println("\n******** MENU *******");
             System.out.println("\n1.PUSH");
             System.out.println("\n2.POP");
             System.out.println("\n3.PEEK");
             System.out.println("\n4 IS EMPTY");
             System.out.println("\n5 DISPLAY");
             System.out.println("\n6.EXIT");
             System.out.println("\n enter ur choice : ");
             switch(in.nextInt())
                {
                 case 1:
                     System.out.println("\nenter the value ");
                     head=s.push(in.nextInt(),head);
                     break;
                 case 2:
                     head=s.pop(head);
                     break;

                case 3:
```

```
System.(
                                    break;
                        case 5: s.display(head);
                                    break;
                        case 6: System.exit(0);
                                    break;
                        default: System.out.println("\n Wrong Choice!");
                                     break;
                       }
                  System.out.println("\n do u want to cont... ");
                 }while(in.nextInt()==1);

        }
}
```

Output

******** MENU *******

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5 DISPLAY

6.EXIT

enter ur choice :

1

enter the value

12

do u wa
1

****

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5 DISPLAY

6.EXIT

enter ur choice :
1

enter the value
56

do u want to cont...
1

******** MENU *******

1.PUSH

2.POP

3.PEEK

4 IS EMPTY

5 DISPLAY

6.EXIT

enter ur choice :
5

```
list is :
56 12
do u wa
1
******** MENU *******
1.PUSH
2.POP
3.PEEK
4 IS EMPTY
5 DISPLAY
6.EXIT
 enter ur choice :
3
 top element : 56
 do u want to cont...
1
******** MENU *******
1.PUSH
2.POP
3.PEEK
4 IS EMPTY
5 DISPLAY
6.EXIT
 enter ur choice :
4
```

is empt.
do u wa
1

Queue

- Linear Data Structure
- Follows FIFO: First In First Out
- Insertion can take place from the rear end.
- Deletion can take place from the front end.
- Eg: queue at ticket counters, bus station
- 4 major operations:
  - enqueue(ele) – used to insert element at top
  - dequeue() – removes the top element from queue
  - peekfirst() – to get the first element of the queue
  - peeklast() – to get the last element of the queue
- All operation works in constant time i.e, O(1)

Advantages

- Maintains data in FIFO manner
- Insertion from beginning and deletion from end takes O(1) time

Applications

- Scheduling
- Maintaining playlist
- Interrupt handling

Demonstration of Queue- using Array

```
import java.util.*;

class Queue{

 int front;
 int rear;
 int[] arr;

 Queue()
 {
  front=rear=-1;
  arr=new int[10];
 }
```

```
void en
{
 if(rear
        System.out.println("overflow");
    else
        arr[++rear]=a;

    if(front==-1)
        front++;
 }

 int dequeue()
 {
  int x=-1;
    if(front==-1)
        System.out.println("underflow");
    else
        x=arr[front++];
    if(rear==0)
       rear--;
    return x;
  }

    void display()
    {
     for(int i=front;i<=rear;i++)
        System.out.print(arr[i]+" ");

     System.out.println();


    }
}

public class QueueDemo{

    public static void main(String[] args)
    {
     Queue ob=new Queue();
     ob.enqueue(1);
     ob.enqueue(2);
     ob.enqueue(3);
```

```
        ob
        ob
        ob
        ob
        ob.display();
        }
}
```

Output:

```
1 2 3 4 5
2 3 4 5
```

Demonstration of Queue- using LinkedList

```
class LNode{

    int data;
    LNode next;

    LNode(int d)
    {
        data=d;
    }
}


class Queue{

    LNode enqueue(LNode head,int a)
    {
        LNode tmp=new LNode(a);
        if(head==null)
            head=tmp;
        else
         {
            LNode tmp1=head;
            while(tmp1.next!=null)
```

```
        return head;
    }

    LNode dequeue(LNode head)
    {
        if(head==null)
            System.out.println("underflow");
          else
                head=head.next;
            return head;
    }

    void display(LNode head)
    {

                System.out.println("\n list is : ");
                if(head==null){

                    System.out.println("no LNodes");

                    return;
                    }

                LNode tmp=head;

                while(tmp!=null){

                System.out.print(tmp.data+" ");

                tmp=tmp.next;


                }
    }

    }

    public class QueueDemoLL{
```

```
            LNode head=null;

            head=ob.enqueue(head,1);
            head=ob.enqueue(head,2);
            head=ob.enqueue(head,3);
            head=ob.enqueue(head,4);
            head=ob.enqueue(head,5);
            ob.display(head);
            head=ob.dequeue(head);
            ob.display(head);
        }
    }
```

Output

```
list is :
1 2 3 4 5
list is :
2 3 4 5
```

Binary Tree

- Hierarchical Data Structure
- Topmost element is known as the root of the tree
- Every Node can have at most 2 children in the binary tree
- Can access elements randomly using index
- Eg: File system hierarchy
- Common traversal methods:
  - preorder(root) : print-left-right
  - postorder(root) : left-right-print
  - inorder(root) : left-print-right

Advantages

- Can represent data with some relationship
- Insertion and search are much efficient

Disadvantages

- Sorting
- Network

Applicat

- File sy
- Multiple variations of the binary tree have a wide variety of applications

Demonstration of Binary Tree

```
class TLNode
{
int data;
TLNode left,right;

TLNode(int d)
{
 data=d;
 }
}


public class BinaryTree
{
  static void preorder(TLNode r)
  {
        if(r==null)
          return;

        System.out.print(r.data+" ");

        preorder(r.left);
        preorder(r.right);

  }
  static void inorder(TLNode r)
  {
        if(r==null)
          return;


        inorder(r.left);
        System.out.print(r.data+" ");
        inorder(r.right);
```

```
    }
    static v
    {
        if(r==null)
            return;

        postorder(r.left);
        postorder(r.right);
        System.out.print(r.data+" ");

    }

    public static void main(String[] args)
    {
        TLNode root=new TLNode(1);

        root.left=new TLNode(2);
        root.right=new TLNode(3);

        root.left.left=new TLNode(4);
        root.left.right=new TLNode(5);

        root.right.left=new TLNode(6);
        root.right.right=new TLNode(7);
        preorder(root);
        System.out.println();

        inorder(root);
        System.out.println();

        postorder(root);
        System.out.println();


    }
}
```

Output

Binary Search Tree

- Binary tree with the additional restriction
- Restriction:
  - The left child must always be less than the root node
  - The right child must always be greater than the root node
- Insertion, Deletion, Search is much more efficient than a binary tree

Advantages

- Maintains order in elements
- Can easily find the min and max Nodes in the tree
- Inorder traversal gives sorted elements

Disadvantages

- Random access not possible
- Ordering adds complexity

Applications

- Suitable for sorted hierarchical data

Demonstration of Binary Search Tree

```
class TLNode{

    int data;
    TLNode left,right;

    TLNode(int d)
    {
        data=d;
    }
}

public class BST{

    TLNode root;

    TLNode insert(int d,TLNode root)
    {
```

```
        if(
            r
    else
            root.left=insert(d,root.left);

        else
            root.right=insert(d,root.right);

        return root;
    }

    TLNode search(int d,TLNode root)
    {
        if(root.data==d)
            return root;
        else if(d<root.data)
            return search(d,root.left);
        else
            return search(d,root.right);
    }



    void inorder(TLNode r)
{
        if(r==null)
            return;


        inorder(r.left);
        System.out.println(r.data);
        inorder(r.right);

}


TLNode delete(TLNode root, int data)
 {

    if (root == null)  return root;

    if (data < root.data)
```

```
    else
    {

      if (root.left == null)
         return root.right;
      else if (root.right == null)
         return root.left;


      root.data = minValue(root.right);

      root.right = delete(root.right, root.data);
    }

    return root;
 }
int minValue(TLNode root)
 {
    int minv = root.data;
    while (root.left != null)
    {
      minv = root.left.data;
      root = root.left;
    }
    return minv;
 }


public static void main(String[] args)
{
        BST ob=new BST();
        ob.root=ob.insert(50,ob.root);
        ob.root=ob.insert(30,ob.root);
        ob.root=ob.insert(20,ob.root);
        ob.root=ob.insert(20,ob.root);
        ob.root=ob.insert(70,ob.root);
        ob.root=ob.insert(60,ob.root);
        ob.root=ob.insert(80,ob.root);
        ob.root=ob.delete(ob.root,50);
```

```
        if(find==null)
            System.out.println("not found");
        else
            System.out.println("found : "+find.data);


    }
}
```

Output:

```
******60
20
20
30
60
70
80
found : 30
```

Heap

- Binary Heap can be visualized array as a complete binary tree
- Arr[0] element will be treated as root
- length(A) – size of array
- heapSize(A) – size of heap
- Generally used when we are dealing with minimum and maximum elements
- For ith node

(i-1)/2	Parent
(2*i)+1	Left child
(2*i)+2	Right Child

Advantages

- Can be of 2 types: min heap and max heap
- Min heap keeps smallest and element and top and max keeps largest
- O(1) for dealing with min or max elements

Disadvantages

- Rando
- Only o

Applicat

- Suitabl
- Scheduling algorithm
- caching

Demonstration of Max Heap

```
import java.util.*;


class Heap{

    int heapSize;

    void build_max_heap(int[] a)
    {
        heapSize=a.length;
        for(int i=(heapSize/2);i>=0;i--)
            max_heapify(a,i);

    }

    void max_heapify(int[] a,int i)
    {
        int l=2*i+1;
        int r=2*i+2;
        int largest=i;
        if(l<heapSize &&a[l]>a[largest])
            largest=l;
        if(r<heapSize &&a[r]>a[largest])
            largest=r;
        if(largest!=i)
        {
            int t=a[i];
            a[i]=a[largest];
            a[largest]=t;
          max_heapify(a,largest);
        }

    }
```

```
        //to
        int
        {
                if(heapSize<0)
                        System.out.println("underflow");
                int max=a[0];
                a[0]=a[heapSize-1];
                heapSize--;
                max_heapify(a,0);
                return max;
        }

        void increase_key(int[] a,int i,int key)
        {
                if(key<a[i])
                        System.out.println("error");
                a[i]=key;
                while(i>=0 && a[(i-1)/2]<a[i])
                {
                        int t=a[(i-1)/2];
                        a[(i-1)/2]=a[i];
                        a[i]=t;

                        i=(i-1)/2;
                }
        }

        void print_heap(int a[])
        {
                for(int i=0;i<heapSize;i++)
                   System.out.println(a[i]+" ");
        }
}

public class HeapDemo{

        public static void main(String[] args)
        {
                Scanner in=new Scanner(System.in);
                int n=in.nextInt();
                int a[]=new int[n];
```

```
        Heap ob=new Heap();

        ob.build_max_heap(a);
        ob.print_heap(a);


        System.out.println("maximum element is : "+ob.extract_max(a));
        ob.print_heap(a);
        System.out.println("maximum element is : "+ob.extract_max(a));
        ob.increase_key(a,6,800);
        ob.print_heap(a);

    }

}
```

Output

```
7
enter the elements of array
50 100 10 1 3 20 5
100
50
20
1
3
10
5
maximum element is : 100
50
5
20
1
3
10
maximum element is : 50
800
5
20
```

- Uses special Hash function
- A hash function maps element to an address for storage
- This provides constant-time access
- Collision is handled by collision resolution techniques
- Collision resolution technique
  - Chaining
  - Open Addressing

Advantages

- The hash function helps in fetching element in constant time
- An efficient way to store elements

Disadvantages

- Collision resolution increases complexity

Applications

- Suitable for the application needs constant time fetching

Demonstration of HashSet – to find string has unique characters

```
import java.util.*;

class HashSetDemo1{

    static boolean isUnique(String s)
    {
        HashSet<Character> set =new HashSet<Character>();

        for(int i=0;i<s.length();i++)
          {
                char c=s.charAt(i);
                if(c==' ')
                    continue;
                if(set.add(c)==false)
                    return false;

          }
```

```
    }
    public static void main(String[] args)
    {
        String s="helo wqty ";
        boolean ans=isUnique(s);
        if(ans)
            System.out.println("string has unique characters");
        else
            System.out.println("string does not have unique characters");




    }
}
```

Output:
string has unique characters

Demonstration of HashMap – count the characters in string

```
 import java.util.*;

class HashMapDemo
{

    static void check(String s)
    {
        HashMap<Character,Integer> map=new HashMap<Character,Integer>();
        for(int i=0;i<s.length();i++)
            {char c=s.charAt(i);
             if(!map.containsKey(c))
                map.put(c,1);
             else
                map.put(c,map.get(c)+1);
            }



        Iterator<Character> itr = map.keySet().iterator();
```

```
        }

        public static void main(String[] args)
        {
                String s="hello";
                check(s);
        }
}
```

Output

```
count of e : 1
count of h : 1
count of l : 2
count of o : 1
```

Demonstration of HashTable – to find string has unique characters

```
 import java.util.*;
class hashTabledemo {
        public static void main(String[] arg)
        {
                // creating a hash table
                Hashtable<Integer, String> h =
                                new Hashtable<Integer, String>();

                Hashtable<Integer, String> h1 =
                                new Hashtable<Integer, String>();

                h.put(3, "Geeks");
                h.put(2, "forGeeks");
                h.put(1, "isBest");

                // create a clone or shallow copy of hash table h
                h1 = (Hashtable<Integer, String>)h.clone();

                // checking clone h1
                System.out.println("values in clone: " + h1);

                // clear hash table h
```


```
        }
}
```

Output

values in clone: {3=Geeks, 2=forGeeks, 1=isBest}

after clearing: {}

values in clone: {3=Geeks, 2=forGeeks, 1=isBest}

Graph

- Basically it is a group of edges and vertices
- Graph representation
  - G(V, E); where V(G) represents a set of vertices and E(G) represents a set of edges
- The graph can be directed or undirected
- The graph can be connected or disjoint

Advantages

- finding connectivity
- Shortest path
- min cost to reach from 1 pt to other
- Min spanning tree

Disadvantages

- Storing graph(Adjacency list and Adjacency matrix) can lead to complexities

Applications

- Suitable for a circuit network
- Suitable for applications like Facebook, LinkedIn, etc
- Medical science

Demonstration of Graph

```
 import java.util.*;

class Graph
{
        int v;
```

```
{
        this.v=v;
        adj=new LinkedList[v];
        for(int i=0;i<v;i++)
                adj[i]=new LinkedList<Integer>();
}


void addEdge(int u,int v)
{
        adj[u].add(v);
}

void BFS(int s)
{
        boolean[] visited=new boolean[v];
        LinkedList<Integer> q=new LinkedList<Integer>();
        q.add(s);
        visited[s]=true;

        while(!q.isEmpty())
        {
                int x=q.poll();
                System.out.print(x+" ");

                Iterator<Integer> itr=adj[x].listIterator();
                while(itr.hasNext())
                {
                 int p=itr.next();
                 if(visited[p]==false)
                        {
                                visited[p]=true;
                                q.add(p);
                        }
                }
        }
}


void DFSUtil(int s,boolean[] visited)
```

```
        {
            Iterator<Integer> itr=adj[s].listIterator();
            while(itr.hasNext())
            {
                int x=itr.next();
                if(visited[x]==false)
                {
                    //visited[x]=true;

                    DFSUtil(x,visited);
                }
            }
        }


        void DFS(int s){
            boolean visited[]=new boolean[v];
            DFSUtil(s,visited);
        }

        public static void main(String[] args)
            {
                Graph g=new Graph(4);
                g.addEdge(0,1);
                g.addEdge(0,2);
                g.addEdge(1,2);
                g.addEdge(2,0);
                g.addEdge(2,3);
                g.addEdge(3,3);

                g.BFS(2);
                g.DFS(2);

            }
}
```

Output:

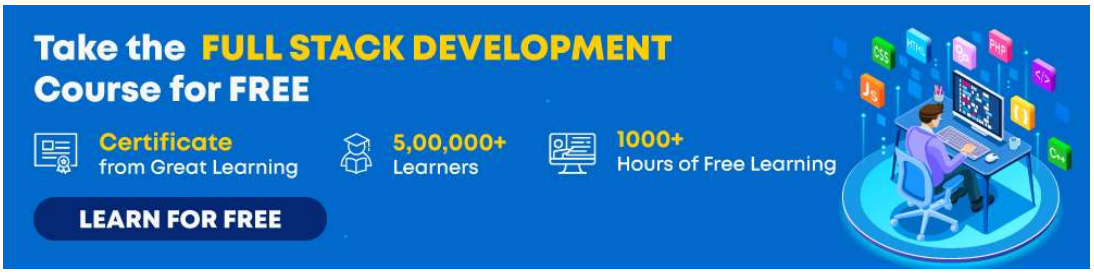
2 0 3 1 2

0

1

3

We hope t
learn mor



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Faizan Parvez

Faizan has been working as an Instructor of Data Structure and Algorithm for the last 1 year. He has expertise in languages such as Java, JavaScript, etc. He is a Subject Matter Expert in the field of Computer Science and a Competitive programmer. He has been working in technical content development and is a Research Analyst.