ECU178 Computer Science: 210CT - Programming, Algorithms and Data Structures Portfolio

Due on Monday, December 15th, 2014

Dr James Shuttleworth

Robert Rigler : 4939377

Contents

Item 1: Week 3 - Linear Search and Duplicate Finder

1. Pseudocode for linear search

This Simple Algorithm demonstrates how to perform a linear search.
Input: This algorithm takes a populated array A and a value to search for v, as parameters.
Output: The Algorithm is a boolean type and returns either True or False respective of whether the v was found in the list or not.

Algorithm 1 LinearSearch

```
procedure BOOL LINEARSEARCH($v$, $A[\,]$)
    for each element $i$ in $A$ do
        if $A[i] = v$ then
            return true
        end if
    end for
return false
end procedure
```

2. Pseudocode for finding duplicates in a list

This algorithm demonstrates how to examine if a list has duplicate entries using a linear search.
Input: This algorithm takes a populated array A as a parameter.
Output: This Algorithm is a boolean type and returns true or false respective of whether a duplicate value is found or not.

Algorithm 2 Examining for duplicates

```
procedure BOOL EXFORDUPES($A[\,]$)
    for each element $i$ in $A[\,]$ do
        for each element $j$ in $A[\,]$ do
            if $A[i] = A[j]$ then
                return true
            end if
        end for
    end for
end procedure
```

Item 2: Week 4 - Time complexities and Big-O notation

1. Describe the runtime bounds of the linear search algorithm

Algorithm 3 LinearSearch

```
procedure BOOL LINEARSEARCH($item$, $list[\,]$)

    for each element $i$ in $list$ do        (n)
        if  $list[i] = list$ then t          (n)
            return true                      (n)
        end if
    end for
return false                                 (1)
end procedure
```

Collecting the line-by-line runtime data from the algorithms gives: $n + n + n + 1$ which is equivalent to: $3n + 1$.
Therefore the time complexity of the algorithm is O(n).

2. Describe the runtime bounds of the duplicate finder algorithm

Algorithm 4 Examining for duplicates

```
procedure BOOL EXFORDUPES($list[\,]$)
    for  each element $i$ in $list[\,]$ do              (n)
        for  each element $j$ in $list[\,]$ do          (n*n)
            if  $list[i] = list[j]$ then                (n*n)
           return true                                  (n*n)
            end if
        end for
    end for
return false                                            (1)
end procedure
```

Collecting the line-by-line runtime data from the algorithms gives: $n + (n * n) + (n * n) + (n * n) + 1$ which is equivalent to: $3n^2 + n + 1$.
Therefore the time complexity of the algorithm is O(n^2)

Additional work: Critical values of relative runtimes

Write a function that determines the critical value at which the relative runtime of two linear algorithms swap.
For this algorithm, I am assuming that $k1$ >$k2$ (Expression 1 >Expression 2, when $n = 0$).
The Algorithm is very simple; While the value of Expression 1 is greater than Expression 2, increase the value of n.
When the Runtime of the algorithms swap, the while-loop exit condition is fulfilled and the current value of n is returned.

Algorithm 5 Relative runtime comparison algorithm

```
procedure CRITVAL($m1, k1, m2, k2$)
    while ($m1 * n + k1$)>($m2 * n + k2$) do
        $n + +$
    end while
return n

end procedure
```

Item 3: Week 6 - Harmonic Series

1. Harmonic Series (Pseudocode)

Use pseudocode to specify a recursive algorithm to compute the nth value of the harmonic series, for some integer n.

The Harmonic series is as follows: $1 + 1/2 + 1/3 + 1/4 + 1/5 + ..1/n$
Input: This algorithm takes two parameters t and n which are the total sum of the algorithm and the number of repetitions, respectively.
Output: This algorithm outputs the value t which is the total sum of the harmonic series.

This procedure uses a while-loop to control the number recursive iterations.
While the number of iterations left is above 0, add the next value to t, decrease the number of iterations by 1 and recursively call the procedure with the new values of t and n.
When the number of iterations left is no longer above 0, the final value of t is returned and the procedure ends.

Algorithm 6 Computing nth value of harmonic series

```
procedure HARM(float $t$, float $n$)
    while $n > 0$ do
        $t \leftarrow t + (1/n)$
        $n - -$
        $HARM(t, n)$
    end while
return t
end procedure
```

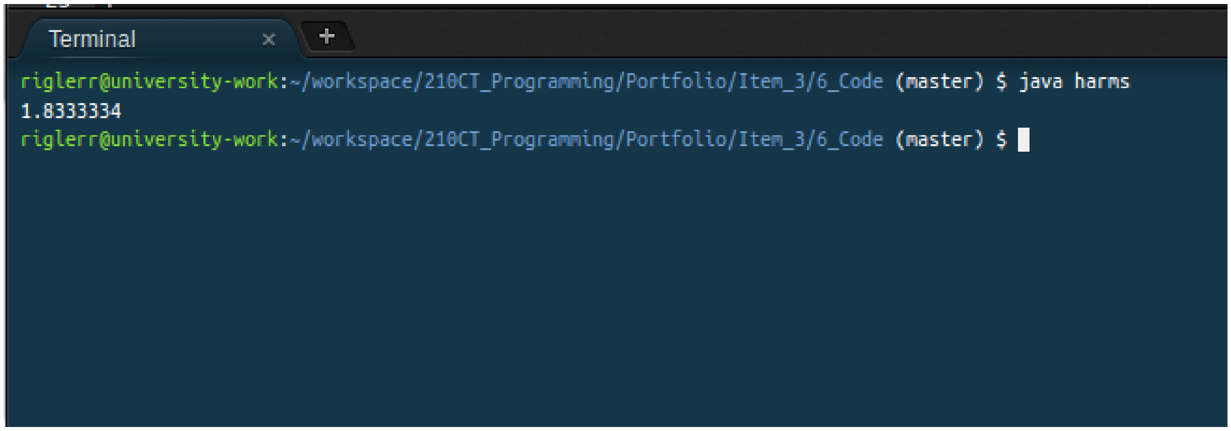
2. Harmonic Series (JAVA Implementation)

The Harmonic Series computation algorithm implemented in Java

Listing 1: harms java class file

```java
public class harms{

    public static void main(String[] args){
        /**/
        System.out.println(f(0,3));
    }

    public static float f(float t, float n){
        /*
        t always has a value of 0 on the initial method call.
        n is the nth term, which decreases by 1 each recursive call.

        When n = 0, stop recursive calling and return the value t.
        */
        while (n>0)
        {
            t+= (1/n);
            f(t,--n);
        }
        return t;
    }


}
```

Evidence of the Harmonic Series computation java implementation.
The nth value passed to the method was 3.



```
riglerr@university-work:~/workspace/210CT_Programming/Portfolio/Item_3/6_Code (master) $ java harms
1.8333334
riglerr@university-work:~/workspace/210CT_Programming/Portfolio/Item_3/6_Code (master) $ 
```

Item 4: Week 7 - RPN Calculator

1. Reverse Polish Notation Calculator

To implement this calculator I created three distinct classes:

- **InputString**: Which handles the string operations.
- **RPN**: This class evaluates the input string and returns an answer.
- **MyStack**: This is the stack class that is capable of Pushing, Poping and Displaying values on the stack.
- **MathOps**: This class handles the mathematical operations.

Below is the code that I wrote in Java:

Listing 2: InputString Class

```
package com.uni;
import com.sun.javafx.fxml.expression.Expression;
import java.util.Scanner;

public class InputString {

    String in_Prompt = " Enter an Input String: ";
    String in_String;

    public InputString(){
     //Class Constructor
        in_String = new String() ;
    }

    public String getIn_String(){
        /**
         * getIn_String Method, gets the USer input from the
         * console and returns it to the caller.
         * Returns null if the Method fails.
         */
        String str_Temp = new String();
        System.out.print(in_Prompt);
        try{
            Scanner in = new Scanner(System.in);
           str_Temp = in.nextLine();
        }
       catch (Exception e){
         System.out.println("getIn_String Method exception: " + e);
           return null;
       }

        return  str_Temp;
    }



    public boolean setIn_String(String str_Val){

        /**
         * Assigns the in_String value from the passed parameter.
         */
        if  (str_Val.isEmpty()){
            System.out.println("
     Method: setIn_String: String parameter is empty.");
            return false;
        }
        else in_String = str_Val;
return true;
    }



    public boolean checkIn_String(){
        char chr_Temp;

   //Checks Each position in the string contains valid characters
        for(int i = 0; i< in_String.length();i++){

             chr_Temp = in_String.charAt(i);
             if(Character.isDigit(chr_Temp) || chr_Temp=='+'
               ||chr_Temp=='-'||chr_Temp=='/' ||chr_Temp=='*'
               ||chr_Temp==' '){

                continue;

            }
            else return false;
        }
        return true;
    }



    public String[] Split_String() {
        //Uses the String.split() method to
     //Convert the Input String to an Array
        String Tokens[];
        Tokens = in_String.trim().split(" ");
      return Tokens;
    }

}
```

Listing 3: RPN Class

```
package com.uni;

public class RPN {

    public static void evalRPN() {

        //Creating the various objects and
     // variable needed for the evaluation/
        InputString Is = new InputString();
        MyStack MS = new MyStack();
        String[] In_arr;
        String Operators = "+-/*";

        //Gets the Users Input.
        //Method only continues if the string is successfully set.
        //And if it only contains valid characters.

        if (Is.setIn_String(Is.getIn_String())) {
            if (Is.checkIn_String()) {

                //Splits the input string into an array.
                In_arr = Is.Split_String();

           //for Each element in the string array,
           //Check if that element is an operator.
           //if Operator: Pop values, do operation and push answer.

                for (String t : In_arr) {
                    if (Operators.contains(t)) {
                        int a = MS.Pop();
                        int b = MS.Pop();

                        switch (t.charAt(0)) {

                            case '+':
                                MS.Push(MathOps.add(a, b));
                                break;
                            case '-':
                                MS.Push(MathOps.sub(b, a));
                                break;


                            case '*':
                                MS.Push(MathOps.mul(a, b));
                                break;
                            case '/':
                                MS.Push(MathOps.div(b, a));
                                break;


                        }
     //Else the element must be pushed to stack.
     //String Must be converted to Integer before pushing to stack.
                    } else MS.Push(Integer.parseInt(t));
                }

            } else System.out.println("String not correct");

        } else System.out.println("String not set");

        //When checked every element in array.
        //Last Push should be the final Answer.
        System.out.println(MS.Pop());

    }
}
```

Listing 4: MyStack Class

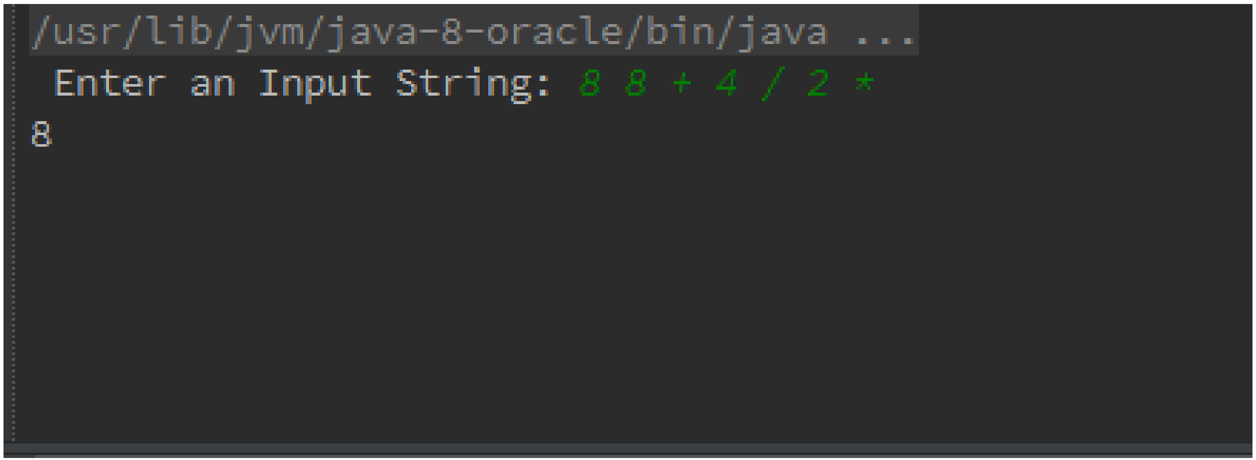
```
package com.uni;
/**
 * Created by Rob on 05/01/2015.
 */
public class MyStack {

  /**
   * This Class represents a stack.
   * An Object of this type will be able to Push()
   * and Pop() values and display the current contents of the stack
   */

    int[] _list ;
    int front;


    public MyStack(){

        _list = new int[10];
        int front = 0;
    }


    public int Push(int val){


  //Increment the front pointer, and store the value in the list.
        try {

            _list[front++] = val;
        }
        //If failure, return error message and 0 to caller
        catch (Exception e){
            System.out.println("Push Method exception: " + e);
            return 0;
        }
        //returns 1 if successful.
        return 1;
    }



    public int Pop(){


        int t;

     //Get the value at the front Pointer
     //Decrement the front pointer
     //Change its previous location to empty (0).
     //Return value.
        try {
            t = _list[--front];
            _list[front] = 0
            return t;
        }
        catch (Exception e){
            System.out.println("Pop Method exception; " + e);
            return  0;
        }

    }

    public void Display(){

        /**
         * Display Method prints the contents of the stack in order
      *from front to back.
         */
        for (int i = front-1; i >=0; i--){
            System.out.println(_list[i]);
        }
        System.out.println();
    }
}
```

Listing 5: MathOps Class

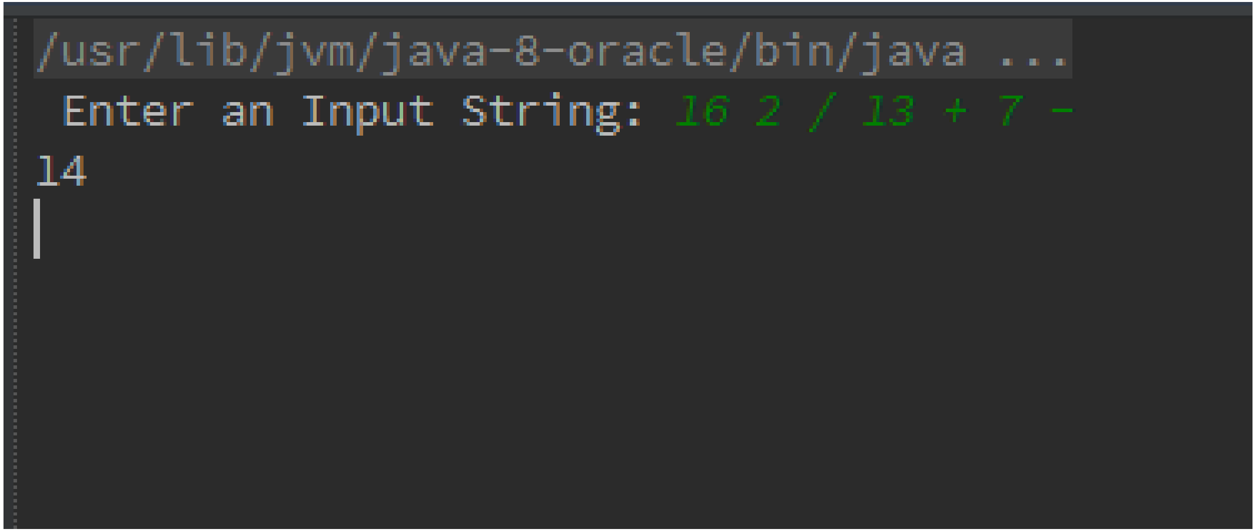
```java
package com.uni;

/**
 * Created by rob on 06/01/15.
 */
public class MathOps {

    public static int add(int val1, int val2){
        return val1+val2;
    }
    public static int sub(int val1, int val2){
        return val1- val2;
    }
    public static int div(int val1, int val2){
        return val1/ val2;
    }
    public static int mul(int val1, int val2){
        return val1*val2;
    }
}
```

Here are the evidence screenshot of the working calculator with these Input Strings:

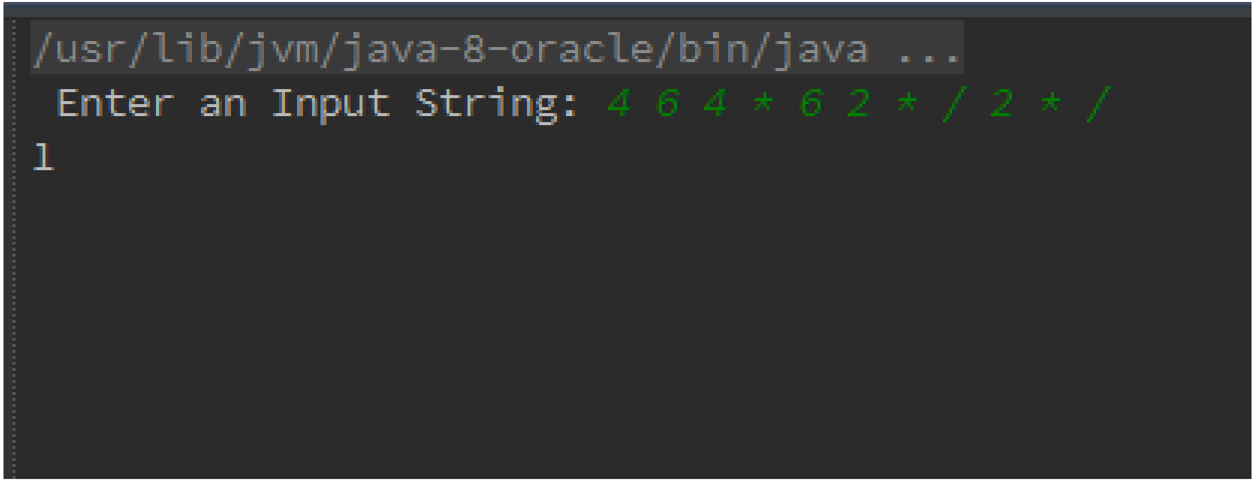
1. $((8+8)/4)*2$ in RPN: 8 8 + 4 / 2 which equals: 8
2. $16/2+13-7$ in RPN: 16 2 / 13 + 7 - which equals: 14
3. $(((6*4)/(6*2))*2)/4$ in RPN: 4 6 4 * 6 2 * / 2 * / which equals: 1



```
/usr/lib/jvm/java-8-oracle/bin/java ...
 Enter an Input String: 8 8 + 4 / 2 *
8
```



```
/usr/lib/jvm/java-8-oracle/bin/java ...
 Enter an Input String: 16 2 / 13 + 7 -
14
```



```
/usr/lib/jvm/java-8-oracle/bin/java ...
 Enter an Input String: 4 6 4 * 6 2 * / 2 * /
1
```

Item 5: Week 8 - Linked List

1. Linked List Implementation

Below are the Linked List and Node classes that I have created as well as a Test class. This is a fully functional doubly Linked List capable of Inserting, Prepending, Deleting and Displaying items in the List. Please see the Evidence Screenshot below:

Listing 6: List Class Implementation: Java

```
package com.company;
public class List {
      //Nodes to hold the head and tail of the list respectively
    Node head;
    Node tail;
    //-----------------------------------------------------------
    //-----------List Constructor to init values to null----------
    //-----------------------------------------------------------
    public List(){
        head = null;
        tail = null;
    }
    //-----------------------------------------------------------
    //----Insert an Element After the specied element (N)---------
    //-----------------------------------------------------------
    public void Insert(Node n, Node x){
        //If previous node exists
        if(n != null){
            //sWAP NODE POINTERS
            x.next = n.next;
            n.next = x;
            x.prev =n;

            // If new node isn't end of list
            if(x.next != null)
                x.next.prev =x;
        }
        //Prepend to existing list
        if (head != null & n == null) {
            n = head;
            n.prev = x;
            x.next = n;
            x.prev = null;
            head = x;
        }



        // If new list (First item to be placed)
       else  if(n == null & head == null)
        {
     //make new node equal to both head and tail
            head = tail =x;
            x.prev =x.next = null; // make head pointers null
        } //If all else exp
        else if(tail == n)
            tail =x;
    }
    //--------------------------------------------------------
    //---------------DELETE A NODE FROM THE LIST---------------
    //--------------------------------------------------------
    public void Delete(Node n){
        //create temporary node
        Node i = head;

        while (i != null){ // Loop until null (tail.next)

            if (i.value == n.value){

                if(i == head){ //If node to remove is head node
                    head = i.next;
                    i.prev = null;
                    break;
                }

          //if node to remove is tail node
                else if (i == tail){
                    tail = i.prev;
                    i.prev.next = null;
                }
                else { // If node to remove is not Head/Tail
                i.prev.next = i.next;
                i.next.prev = i.prev;
                break;}
            }
            i=i.next; // Increment
        }
    }



    //--------------------------------------------------------
    //-----------DISPLAY ALL NODES IN LIST------------------
    //--------------------------------------------------------
    public void display(){
        Node i = head;

        while(i != null) {
            System.out.print(i.value + ", ");
            i = i.next;
        }
    }


}
```

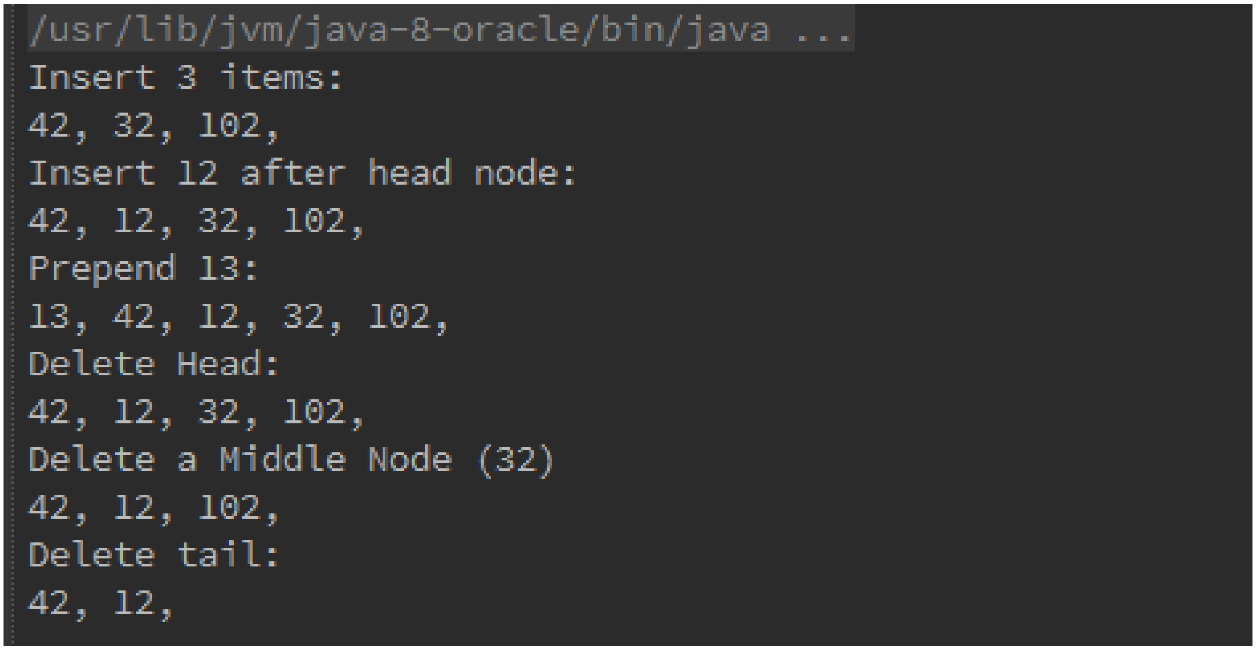
Listing 7: Node Class Implementation: Java

```
package com.company;

/**
 * Created by rob on 20/12/14.
 */

public class Node {
    int value;
    Node prev;
    Node next;

    public Node(int val){

            //Node Constructor
        value = val;
        next =null;
        prev =null;

    }


}
```

Listing 8: Test class

```
package com.company;

public class Main {

    public static void main(String[] args) {
        List obj1 = new List();


        obj1.Insert(null, new Node(42));
        obj1.Insert(obj1.head, new Node(32));
        obj1.Insert(obj1.head.next, new Node(102));

        //----------------------------------------------------
        //----------------Test Inserting Tail-----------------
        //----------------------------------------------------
        System.out.println("Insert 3 items:");
        obj1.display();
        System.out.println();

        // ----------------------------------------------------
        //-----------------Test Insert Between-----------------
        //-----------------------------------------------------
        //Insert 12 between the head node and the head.next
        System.out.println("Insert 12 after head node: ");
        obj1.Insert(obj1.head, new Node(12));
        obj1.display();
        System.out.println();

        //-----------------------------------------------------
        //--------------------Test Prepend---------------------
        //-----------------------------------------------------
        //Insert 13 at start of pre-existing list
        System.out.println("Prepend 13: ");
           obj1.Insert(null,new Node(13));
           obj1.display();
          System.out.println();





        //-----------------------------------------------------
        //------------------Test Delete Head-------------------
        //-----------------------------------------------------
        //Delete the head node '13' from the list
        System.out.println("Delete Head: ");
        obj1.Delete(new Node(13));
        obj1.display();
        System.out.println();

        //------------------------------------------------------
        //------------------Test Delete Norm--------------------
        //------------------------------------------------------
        //Delete a middle node (32) from list an display
        System.out.println("Delete a Middle Node (32)");
        obj1.Delete(new Node(32));
        obj1.display();
        System.out.println();

        //----------------------------------------------------
        //----------------Test Delete Tail--------------------
        //----------------------------------------------------
        //Delete the tail node '42' from list an display
        System.out.println("Delete tail: ");
        obj1.Delete(new Node(102));
        obj1.display();
        System.out.println();


    }}
```

Evidence of working linked list using the Test class shown above:



```
/usr/lib/jvm/java-8-oracle/bin/java ...
Insert 3 items:
42, 32, 102,
Insert 12 after head node:
42, 12, 32, 102,
Prepend 13:
13, 42, 12, 32, 102,
Delete Head:
42, 12, 32, 102,
Delete a Middle Node (32)
42, 12, 102,
Delete tail:
42, 12,
```