College of Engineering Trivandrum

Data Structures Lab

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Contents

CSL 201-Data Structures Lab - Cycle 2

Part-2

1 Binary Search Tree

1.1 Problem

Create a binary Search Tree with the following operations
a. Insert a new node
b. Inorder traversal
c. Preorder traversal
d. Postorder traversal
e. Delete a node

1.2 Algorithm

Algorithm 1:Binary Search Tree Operations

```
Declare structure treeNode with data,treeNode*lc and treeNode*rc as members

START OF FUNCTION inorder(treeNode *root)
If(root!=NULL)
    inorder(root->lc)
    Print root->data
    inorder(root->rc)
End If
END OF FUNCTION inorder

START OF FUNCTION postorder(treeNode* node)
If(node!=NULL)
    postorder(node->lc)
    postorder(node->rc)
    Print node->data
End if
END OF FUNCTION postorder

START OF FUNCTION preorder(treeNode* node)
If(node!=NULL)
    Print node->data
    preorder(node->lc)
    preorder(node->rc)
End if
END OF FUNCTION preorder
```

```
START OF FUNCTION insertIntoTree(treeNode* root, int data)
/*Insert into the binary search tree node with value="data" and return the
root of the tree*/
If(root==NULL)
     Allocate memory for ptr
     ptr->data=data
     ptr->lc=NULL
     ptr->rc=NULL
     root=ptr
Else
      If(root->data>data)
         root->lc=insertIntoTree(root->lc, data)
      Else if(root->data<data)
         root->rc=insertIntoTree(root->rc, data)
      End if
End if
Return root
END OF FUNCTION insertIntoTree

START OF FUNCTION  deleteFromTree(struct treeNode* root, int data)
//Delete from the BST node with value = "data" and then return root of the tree
ptr=root
flag=0
While(ptr!=NULL and flag==0) do
     If (data<ptr->data)
         parent=ptr
         ptr=ptr->lc
     Else if(data>ptr->data)
         parent=ptr
         ptr=ptr->rc
     Else set flag=1
     End if
End While
If(flag==0) Return root
Else
    If(ptr->lc==NULL and ptr->rc==NULL)
          If(parent->lc==ptr)
                parent->lc=NULL
          Else
                parent->rc=NULL
          End if
    Else if(ptr->lc && ptr->rc)
          ptr1=ptr->rc
          If(ptr1!=NULL)
             While(ptr1->lc!=NULL)
                   ptr1=ptr1->lc
             End while
          End if
```

```
          i=ptr1->data
          deleteFromTree(root,i)
          ptr->data=i
    Else
          If(parent->lc==ptr)
               If(ptr->lc==NULL)
                     parent->lc=ptr->rc
               Else
                     parent->lc=ptr->lc
               End if
          Else if(parent->rc==ptr)
               If(ptr->lc==NULL)
                     parent->rc=ptr->rc
               Else
                     parent->rc=ptr->lc
               End if
         End if
    End if
End if
Return root
END OF FUNCTION deleteFromTree

START OF MAIN FUNCTION
root = NULL
Input option opt
While(opt!=6)
    Switch(opt){
         Case 1: Input data
                 root = insertIntoTree(root,data)
                 break
         Case 2: Input data
                 root = deleteFromTree(root,data)
                 break
         Case 3: inorder(root)
                 break
         Case 4: preorder(root)
                 break
         Case 5: postorder(root)
                 break
    End switch-case
    Input opt
End while
END OF MAIN FUNCTION
```

1.3 Code

```
#include <math.h>
```

```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>

typedef struct treeNode{
    int data;
    struct treeNode *lc;
    struct treeNode *rc;
}treeNode;

void inorder(treeNode *root) {
    if(root){
        inorder(root->lc);
        printf("%d ",root->data);
        inorder(root->rc);

    }
}

void postorder(treeNode* node){
    if(node){
        postorder(node->lc);
        postorder(node->rc);
        printf("%d ",node->data);
    }
}

void preorder(treeNode* node) {
    if(node){
        printf("%d ",node->data);
        preorder(node->lc);
        preorder(node->rc);
    }
}

treeNode* insertIntoTree(treeNode* root, int data){
    if(root==NULL){
        treeNode*ptr;
        ptr=malloc(sizeof(treeNode));
        ptr->data=data;
        ptr->lc=NULL;
        ptr->rc=NULL;
        root=ptr;
    }
    else{
```

```
            if(root->data>data){
                root->lc=insertIntoTree(root->lc, data);
            }
            else if(root->data<data) {
                root->rc=insertIntoTree(root->rc, data);
            }
    }
    return root;
}

treeNode* deleteFromTree(struct treeNode* root, int data)
{
    treeNode *ptr=root,*parent;
    int flag=0;
    while(ptr!=NULL && flag==0){
        if (data<ptr->data) {
            parent=ptr;
            ptr=ptr->lc;
        }
        else if(data>ptr->data){
            parent=ptr;
            ptr=ptr->rc;
        }
        else flag=1;
    }
    if(flag==0) return root;
    else{
        if(ptr->lc==NULL && ptr->rc==NULL){
            if(parent->lc==ptr)
               parent->lc=NULL;
            else
               parent->rc=NULL;
        }
        else if(ptr->lc && ptr->rc){
            treeNode*ptr1=ptr->rc;
            if(ptr1){
                while(ptr1->lc)
                  ptr1=ptr1->lc;
            }
            int i=ptr1->data;
            deleteFromTree(root,i);
            ptr->data=i;
        }
        else{
            if(parent->lc==ptr){
                if(ptr->lc==NULL)
                   parent->lc=ptr->rc;
                else
```

```
                parent->lc=ptr->lc;
            }
            else if(parent->rc==ptr){
                if(ptr->lc==NULL)
                    parent->rc=ptr->rc;
                else
                    parent->rc=ptr->lc;
            }
        }
        return root;
    }
}
int main(){
    treeNode* root;
    root = NULL;
    int opt,data;
    do{
        scanf("%d",&opt);
        switch(opt){
            case 1: scanf("%d",&data);
                    root = insertIntoTree(root,data);
                    break;
            case 2: scanf("%d",&data);
                    root = deleteFromTree(root,data);
                    break;
            case 3: inorder(root);
                    printf("\n");
                    break;
            case 4: preorder(root);
                    printf("\n");
                    break;
            case 5: postorder(root);
                    printf("\n");
                    break;
        }
    }while(opt != 6);
    return 0;
}
```

1.4 Sample output

Compiled successfully. All available test cases passed

- Test case 0
- Test case 1
- Test case 2

```
10  6
```

Your Output (stdout)

```
1  2 6 10
2  6 2 10
3  2 10 6
```

Expected Output

```
1  2 6 10
2  6 2 10
3  2 10 6
```

Compiled successfully. All available test cases passed

- Test case 0
- Test case 1
- Test case 2

Your Output (stdout)

```
1  1 2 3 4 5 6 7 10 13 14 15 16 17 18 19
2  1 2 4 5 6 7 10 13 14 15 16 17 18 19
3  1 2 4 6 7 10 13 14 15 16 17 18 19
4  1 2 4 6 7 10 13 14 15 16 17 19 20
5  1 2 4 6 7 13 14 15 17 19 20
6  13 4 2 1 7 6 17 14 15 19 20
```

1.5 Result

Program submitted and executed successfully in HackerRank Platform via user id aishwaryaaj2002

2 Graphs

2.1 Problem

Represent any given graph and
a. Compute adjacency list, adjacency matrix.
b. Perform a depth first search
c. Perform a breadth first search

2.2 Adjacency List and Adjacency Matrix

2.2.1 Algorithm-Adjacency List

Algorithm 2.a.1 :Adjacency List

```
Declare self-referential structure AdjacencyList with value and link as
members.Declare array AdjacencyList g[size] with size =10

START OF FUNCTION insert_to_graph(AdjacencyList * g,int parent,int value)
ptr=g[parent]
g[parent].value=parent
Allocate memory for node
node->value=value
node->link=NULL
While(ptr->link!=NULL)
    ptr=ptr->link
End while
ptr->link=node
END OF FUNCITON insert_to_graph

START OF FUNCTION delete_from_graph(AdjacencyList * g,int value)
Set flag=0
If((g+value)->link!=NULL)
    (g+value)->link=NULL
    flag=1
EndIf
For i from 0 to size-1
    If(i!=value)
        ptr=g+i
        While(ptr->link!=NULL and ptr->value!=value)
            p=ptr
            ptr=ptr->link
        End While
        If(ptr->value==value)
            p->link=ptr->link
            flag=1
        EndIf
    EndIf
End For
```

```
 If(flag==0)
    Print "Node does not exist !"
 EndIf
END OF FUNCTION delete_from_graph

START OF FUNCTION print_graph(AdjacencyList * g)
 Set flag=0
 ptr=(g+i)
 For i from 0 to size-1
   If((g+i)->link!=NULL)
        flag=1
        ptr=(g+i)
        Print "i ->"
        While(ptr->link!=NULL)
            Print ptr->link->value
            ptr=ptr->link
        EndWhile
   EndIf
 End For
 If(flag==0)
     Print "Graph Empty !"
 EndIf
END OF FUNCTION print_graph

START OF MAIN FUNCTION
 Allocate memory for g
 g->link=NULL
 While(1)
   Input choice
   Switch(choice){
        Case 1: Input parent and value for insertion
                insert_to_graph(g, parent, value)
                break
        Case 2: Input value
                delete_from_graph(g,value)
                break
        Case 3: print_graph(g)
                break
        Case 4: return 0
   End switch-case
 End while
END OF MAIN FUNCTION
```

2.2.2 Code-Adjacency List

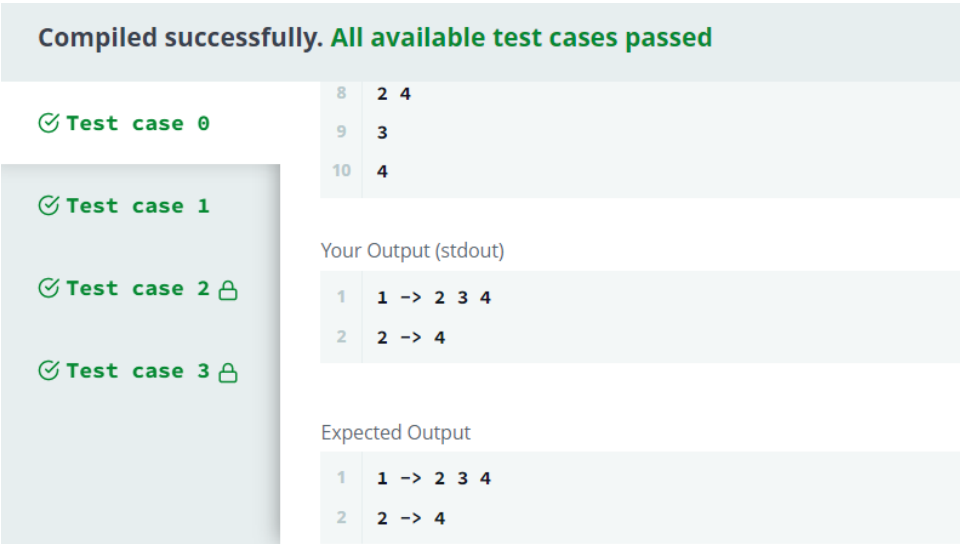
```
#include <math.h>
#include <stdio.h>
#include <string.h>
```

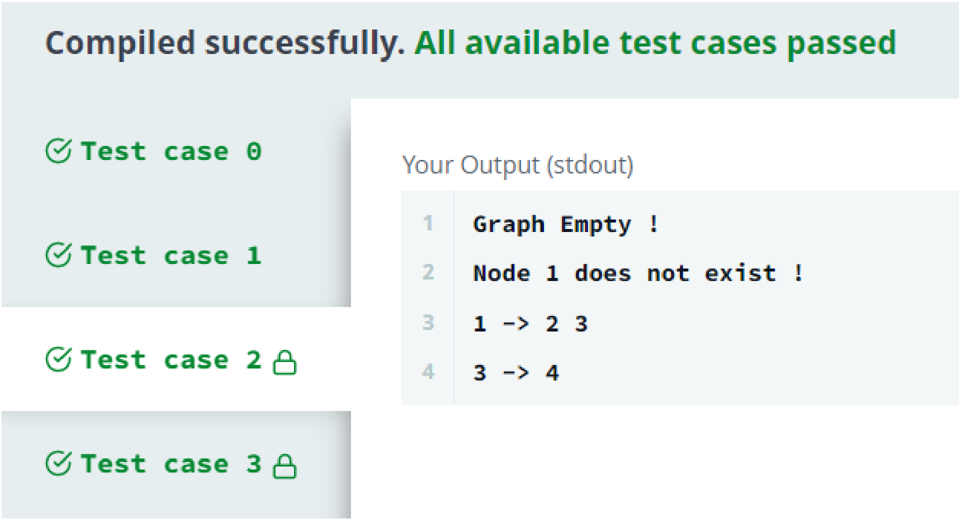
```c
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>
typedef struct AdjacencyList
{
    int value;
    struct AdjacencyList*link;
}AdjacencyList;
AdjacencyList g[10];
void insert_to_graph(AdjacencyList * g,int parent,int value)
{
    AdjacencyList*ptr=g+parent,*node;
    g[parent].value=parent;
    node=(AdjacencyList*)malloc(sizeof(AdjacencyList));
    node->value=value;
    node->link=NULL;
    while(ptr->link!=NULL)
        ptr=ptr->link;
    ptr->link=node;
}

void delete_from_graph(AdjacencyList * g,int value)
{
   AdjacencyList*ptr,*p;
   int flag=0;
   if((g+value)->link){
   (g+value)->link=NULL;
   flag=1;
   }
   for(int i=0;i<10;i++){
      if(i!=value){
            ptr=g+i;
            while(ptr->link && ptr->value!=value){
                 p=ptr;
                ptr=ptr->link;
            }
            if(ptr->value==value){
                p->link=ptr->link;
                flag=1;
            }
       }
   }
   if(flag==0){
        printf("Node %d does not exist !\n",value);
   }

}
```

```
void print_graph(AdjacencyList * g)
{
    int i,flag=0;
    AdjacencyList*ptr=(g+i);
    for(i=0;i<10;i++){
        if((g+i)->link){
            flag=1;
            AdjacencyList*ptr=(g+i);
            printf("%d ->",i);
            while(ptr->link){
              printf(" %d",ptr->link->value);
              ptr=ptr->link;
            }
            printf("\n");
        }
    }
    if(flag==0)
      printf("Graph Empty !\n");
}

int main() {
    AdjacencyList * g = (AdjacencyList *)malloc(sizeof(AdjacencyList)*10);
    g->link=NULL;
    while(1)
    {
        int choice;
        scanf("%d",&choice);
        switch(choice)
        {
            case 1:
            {
                int parent,value;
                scanf("%d %d",&parent,&value);
                insert_to_graph(g,parent,value);
            }
            break;

            case 2:
            {
                int value;
                scanf("%d",&value);
                delete_from_graph(g,value);
            }
            break;

            case 3:
            {
```

```
                    print_graph(g);
                }
                break;

                case 4:
                {
                    return 0;
                }
            }
        }
        return 0;
}
```

2.2.3 Sample output





2.2.4 Algorithm-Adjacency Matrix

Algorithm 2.a.2 :Adjacency Matrix

```
Declare a structure AdjacencyMatrix with mat[size][size] as member
with size =10

START OF FUNCTION insert_to_graph(AdjacencyMatrix*g,int parent,int value)
   g->mat[parent][value] =1
END OF FUNCITON insert_to_graph

START OF FUNCTION delete_from_graph(AdjacencyMatrix * g,int value)
Set flag=0
For i from 0 to size-1
    If(g->mat[value][i]==1)
        g->mat[value][i]=0
        flag=1
    Else If(g->mat[i][value]==1)
        g->mat[i][value]=0
        flag=1
    EndIf
End For
If(flag==0)
    Print "Node does not exist !"
EndIf
END OF FUNCTION delete_from_graph

START OF FUNCTION print_graph(AdjacencyMatrix * g)
Set n=-1,count=0,flag=0
For i from 0 to size-1
   For i from 0 to size-1
```

```
        If(g->mat[i][j]==1)
            If(i==n)
                Print j
            Else
                If(count!=0)
                    Print "\n"
                EndIf
                Print i,j
                n=i
                count=count+1
            EndIf
            flag=1
       EndIf
   End For
 End For
 If(flag==0)
     Print "Graph Empty !"
 EndIf
 END OF FUNCTION print_graph

 START OF MAIN FUNCTION
 Allocate memory for g
 While(1)
   Input choice
   Switch(choice){
       Case 1: Input parent and value for insertion
               insert_to_graph(g, parent, value)
               break
       Case 2: Input value
               delete_from_graph(g,value)
               break
       Case 3: print_graph(g)
               break
       Case 4: return 0
   End switch-case
 End while
 END OF MAIN FUNCTION
```

2.2.5 Code-Adjacency Matrix

```
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>
```

```c
typedef struct AdjacencyMatrix
{
    int mat[10][10];
}AdjacencyMatrix;
AdjacencyMatrix *g;

void insert_to_graph(AdjacencyMatrix * g,int parent,int value)
{
    g->mat[parent][value] =1;
}

void delete_from_graph(AdjacencyMatrix * g,int value)
{
    int flag=0;
    for(int i=0;i<10;i++){
        if(g->mat[value][i]==1){
            g->mat[value][i]=0;
            flag=1;
        }
        else if(g->mat[i][value]==1){
            g->mat[i][value]=0;
            flag=1;
        }
    }
    if(flag==0)
      printf("Node %d does not exist !\n",value);
}

void print_graph(AdjacencyMatrix * g)
{
    int n=-1,count=0,flag=0;
    for(int i=0;i<10;i++){
        for(int j=0;j<10;j++){
            if(g->mat[i][j]==1){
                if(i==n)
                  printf(" %d",j);
                else{
                  if(count!=0) printf("\n");
                  printf("%d -> %d",i,j);
                  n=i;
                  count++;
                  }
                flag=1;
            }
        }
    }
    if(flag==0)
      printf("Graph Empty !\n");
```

```
}

int main() {
    AdjacencyMatrix * g = (AdjacencyMatrix *)malloc(sizeof(AdjacencyMatrix));
    while(1)
    {
        int choice;
        scanf("%d",&choice);
        switch(choice)
        {
            case 1:
            {
                int parent, value;
                scanf("%d %d",&parent,&value);
                insert_to_graph(g, parent, value);
            }
            break;

            case 2:
            {
                int value;
                scanf("%d",&value);
                delete_from_graph(g, value);
            }
            break;

            case 3:
            {
                print_graph(g);
            }
            break;

            case 4:
            {
                return 0;
            }
        }
    }
    return 0;
}
```

2.2.6 Sample output

2.3 Depth First Search

2.3.1 Algorithm

Algorithm 2.b :Depth First Search

```
Declare a structure AdjacencyMatrix with mat[size][size] as member
with size =10
START OF FUNCTION insert_to_graph(AdjacencyMatrix*g,int parent,int value)
  g->mat[parent][value] =1
  g->mat[value][parent] =1
END OF FUNCITON insert_to_graph

Node is a Self Referential structure with val and node* next as members
START OF FUNCTION DISPLAY(node* list) \\list points to first node
While (list!=NULL)
    Print list->val
    list=list->next
End While
END OF FUNCTION DISPLAY

START OF FUNCTION INSERT_AT_END(node* list,int val)
Allocate memory for new node temp
temp->val=val
temp->next=NULL
If(list==NULL)
    list=temp
    Return list
Else
    first =list
    While(list->next!=NULL)
         list=list->next
    End While
    list->next=temp
    Return first
End If
END OF FUNCTION INSERT_AT_END

START OF FUNCTION search(node *list,data)
While (list!=NULL and list->val!=data)
    list=list->next
End While
If(list==NULL)
    return 1
End If
return 0
END OF FUNCTION search

Declare self referential structure Stack with data and next (which points
```

```
to the Stack) as members
START OF FUNCTION push(Stack * top, int data)
Allocate memory for ptr
ptr->data=data
ptr->next=top
top=ptr
END OF FUNCTION push

START OF FUNCTION pop(Stack * top)
If(top!=NULL)
   ptr=top
   top=top->next
   Deallocate memory for ptr
End If
END OF FUNCTION pop

START OF FUNCTION dfs(AdjacencyMatrix*g,int startnode)
visit=NULL
v=startnode
push(top,v)
While(top!=NULL)
    v=pop(top)
    If(search(visit, v)==1)
         visit=insertAtEnd(visit,v)
         For i from 0 to size-1
              If(g->mat[v][i]==1)
                   push(top2,i)
              EndIf
         End For
         While(top2)
              push(top,pop(top2))
         End While
    End If
End While
display(visit)
END OF FUNCTION dfs

START OF MAIN FUNCTION
Allocate memory for g
Input no. of edges n
For i from 0 to n-1
    Input nodes a,b
    insert_to_graph(g, a,b)
End For
Input startnode sn
dfs(g,sn)
END OF MAIN FUNCTION
```

2.3.2 Code

```
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>
typedef struct AdjacencyMatrix
{
    int mat[10][10];
}AdjacencyMatrix;
AdjacencyMatrix *g;
void insert_to_graph(AdjacencyMatrix * g,int parent,int value)
{
    g->mat[parent][value] =1;
    g->mat[value][parent] =1;
}

typedef struct Stack
{
    int data;
    struct Stack* next;
}Stack;
Stack* top=NULL,*top2=NULL;

typedef struct node{
    int val;
    struct node *next;
}node;

void display(node* list){
    while(list!=NULL){
        printf("%d ",list->val);
        list=list->next;
    }
}
node* insertAtEnd(node* list ,int val){
    node* temp;
    temp=(node*)malloc(sizeof(node));
    temp->val=val;
    temp->next=NULL;
    if(list==NULL)
    {
        list=temp;
        return list;
    }
```

```
    else
    {
        node*first =list;
        while(list->next!=NULL)
            list=list->next;
        list->next=temp;
        return first;
    }
}
int search(node *list,int data){
    while(list && list->val!=data){
        list=list->next;
    }
    if (list==NULL)
      return 1;
    else return 0;
}
void push(Stack**top,int data)
{
    Stack* ptr;
    ptr=(Stack*)malloc(sizeof(Stack));
    ptr->data=data;
    ptr->next=*top;
    *top=ptr;
}

int pop(Stack**top)
{
    int item;
    Stack*ptr=*top;
    item=(*top)->data;
    (*top)=(*top)->next;
    free(ptr);
    return item;
}
void dfs(AdjacencyMatrix*g,int startnode)
{
    node *visit=NULL;
    int v=startnode;
    push(&top,v);
    AdjacencyMatrix*ptr;
    while(top!=NULL){
        v=pop(&top);
        if(search(visit, v)==1){
            visit=insertAtEnd(visit,v);
            for(int i=0;i<10;i++){
                if(g->mat[v][i]==1)
                 push(&top2,i);
```

```
            }
            while(top2){
                push(&top, pop(&top2));
            }
        }
    }
    display(visit);
}
int main() {
    AdjacencyMatrix * g = (AdjacencyMatrix *)malloc(sizeof(AdjacencyMatrix));
    int n,a,b,sn;
    scanf("%d",&n);
    for(int i=0;i<n;i++){
        scanf("%d %d",&a,&b);
        insert_to_graph(g, a,b);
    }
    scanf("%d",&sn);
    dfs(g,sn);
    return 0;
}
```

2.3.3 Sample output

2.4 Breadth First Search

2.4.1 Algorithm

Algorithm 2.c :Breadth First Search

```
Declare a structure AdjacencyMatrix with mat[size][size] as member
with size =10
START OF FUNCTION insert_to_graph(AdjacencyMatrix*g,int parent,int value)
  g->mat[parent][value] =1
  g->mat[value][parent] =1
END OF FUNCITON insert_to_graph

Node is a Self Referential structure with val and node* next as members
START OF FUNCTION display(node* list) \\list points to first node
While (list!=NULL)
    Print list->val
    list=list->next
End While
END OF FUNCTION display

START OF FUNCTION insert_at_end(node* list,int val)
Allocate memory for new node temp
temp->val=val
temp->next=NULL
If(list==NULL)
    list=temp
    Return list
Else
    first =list
    While(list->next!=NULL)
         list=list->next
    End While
    list->next=temp
    Return first
End If
END OF FUNCTION insert_at_end

START OF FUNCTION search(node *list,data)
While (list!=NULL and list->val!=data)
    list=list->next
End While
If(list==NULL)
    return 1
End If
return 0
END OF FUNCTION search

queue is a self referential structure with front,rear and queue*link
```

```
as members
front=rear=NULL
START OF FUNCTION enqueue(int k)
If(front==NULL)
    Allocate memory for rear
    front=rear
    rear->data=k
    rear->link=NULL
Else
    temp=rear
    Allocate memory for ptr
    ptr->data=k
    rear=ptr
    temp->link=rear
    rear->link=NULL
End if
END OF FUNCTION enqueue

START OF FUNCTION dequeue()
ptr=front
item=ptr->data
front=ptr->link
Deallocate memory for ptr
Return item
END OF FUNCTION dequeue

START OF FUNCTION is_empty()
If(front==NULL)
     Return 1
Else
     Return 0
End if
END OF FUNCTION is_empty

START OF FUNCTION bfs(AdjacencyMatrix*g,int startnode)
visit=NULL
v=startnode
enqueue(v)
While(is_empty!=0)
     v=dequeue()
     If(search(visit , v)==1)
          visit=insertAtEnd(visit ,v)
          For i from 0 to size-1
               If(g->mat[v][i]==1)
                    enqueue(i)
               EndIf
          End For
     End If
```

```
End While
display(visit)
END OF FUNCTION bfs

START OF MAIN FUNCTION
Allocate memory for g
Input no. of edges n
For i from 0 to n-1
    Input nodes a,b
    insert_to_graph(g, a,b)
End For
Input startnode sn
bfs(g,sn)
END OF MAIN FUNCTION
```

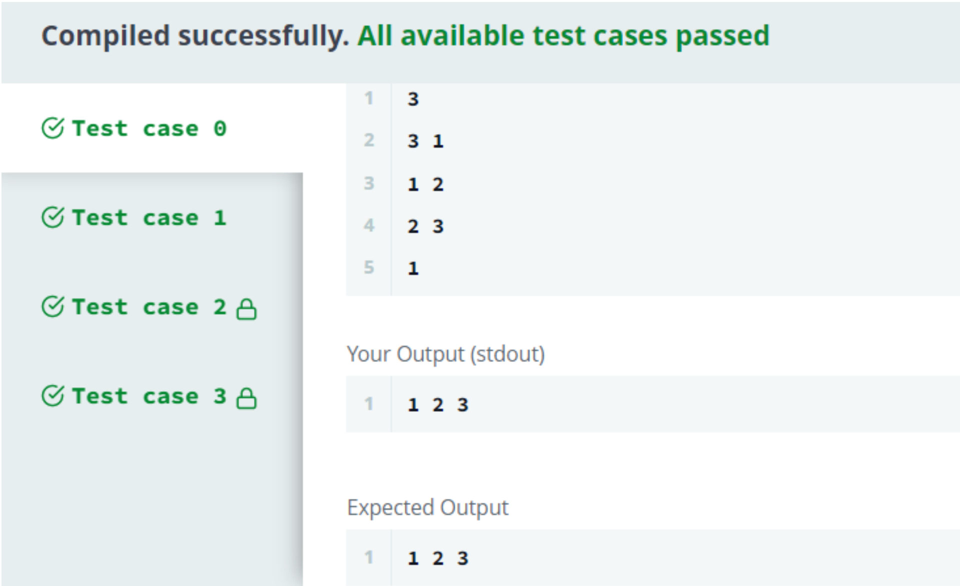
2.4.2 Code

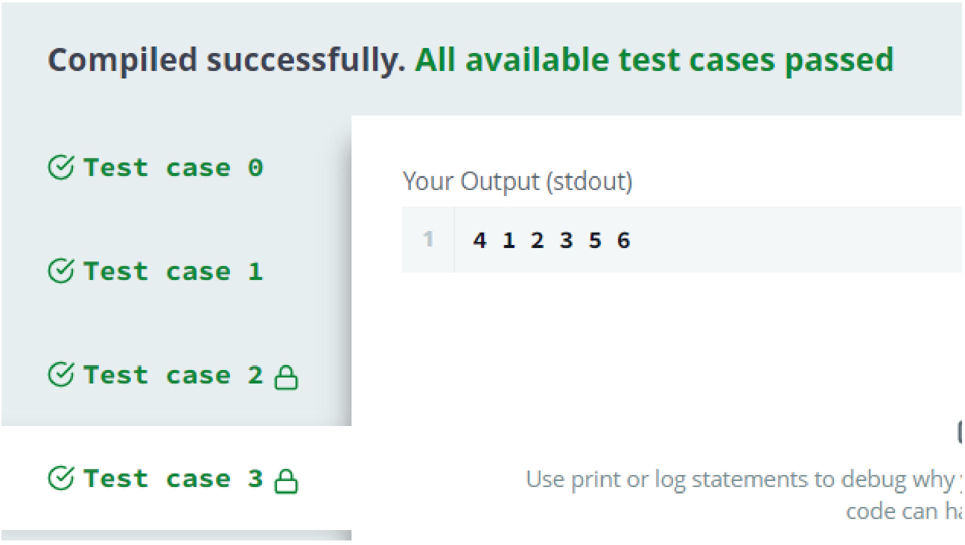
```c
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>
typedef struct AdjacencyMatrix
{
    int mat[10][10];
}AdjacencyMatrix;
AdjacencyMatrix *g;

typedef struct node{
    int val;
    struct node *next;
}node;

typedef struct queue{
    int data;
    struct queue* link;
}queue;
queue* rear=NULL,*front=NULL;

void insert_to_graph(AdjacencyMatrix * g,int parent,int value)
{
    g->mat[parent][value] =1;
    g->mat[value][parent] =1;
}
```

```
void enqueue(int k){
    if(front==NULL){
        rear=(queue*)malloc(sizeof(queue));
        front=rear;
        rear->data=k;
        rear->link=NULL;
    }
    else{
        queue*temp=rear;
        queue *ptr=malloc(sizeof(queue));
        ptr->data=k;
        rear=ptr;
        temp->link=rear;
        rear->link=NULL;
    }
}

int dequeue(){
    queue*ptr=front;
    int item=ptr->data;
    front=ptr->link;
    free(ptr);
    return item;
}
int is_empty(){
    if(front==NULL)
      return 1;
    return 0;
}
void display(node* list){
    while(list!=NULL){
       printf("%d ",list->val);
       list=list->next;
    }
}
node* insertAtEnd(node* list,int val){
    node* temp;
    temp=(node*)malloc(sizeof(node));
    temp->val=val;
    temp->next=NULL;
    if(list==NULL)
    {
        list=temp;
        return list;
    }
    else
    {
        node*first =list;
```

```
        while(list->next!=NULL)
            list=list->next;
        list->next=temp;
        return first;
    }
}
int search(node *list ,int data){
    while(list && list->val!=data){
        list=list->next;
    }
    if (list==NULL)
      return 1;
    else return 0;
}


void bfs(AdjacencyMatrix*g,int startnode){
    node *visit=NULL;
    int v=startnode;
    enqueue(v);
    AdjacencyMatrix*ptr;
    while(is_empty()==0){
        v=dequeue();
        if(search(visit, v)==1){
            visit=insertAtEnd(visit,v);
            for(int i=0;i<10;i++){
                if(g->mat[v][i]==1)
                    enqueue(i);
            }
        }
    }
    display(visit);
}

int main() {
    AdjacencyMatrix * g = (AdjacencyMatrix *)malloc(sizeof(AdjacencyMatrix));
    int n,a,b,sn;
    scanf("%d",&n);
    for(int i=0;i<n;i++){
        scanf("%d %d",&a,&b);
        insert_to_graph(g, a,b);
    }
    scanf("%d",&sn);
    bfs(g,sn);
    return 0;
}
```

2.4.3 Sample output





2.5 Result

Program submitted and executed successfully in HackerRank Platform via user id aishwaryaaj2002

3 Sorting Techniques

3.1 Problem

Implement following sorting techniques
a. Heap Sort
b. Merge Sort
c. Quick Sort

3.2 Heap Sort

3.2.1 Algorithms

Algorithm 3.a :Heap Sort Algorithm

```
START OF FUNCTON insert(int* ar,int n,int item)
n=n+1
p = n
While (p > 1)
     par = p / 2
     If (item <= ar[par])
         ar[p] = item
         return
     EndIf
     ar[p] = ar[par]
     p = par
End While
ar[1] = item
END OF FUNCTION insert

START OF FUNCTION delete(int*ar,int n,int item)
item=ar[1]
last=ar[n]
n=n-1
Set p=1,left=2,right=3
While(right<=n)
     If(last>=ar[left] and last>=ar[right])
         ar[p]=last
         return
     EndIf
     If(ar[right]<=ar[left])
         ar[p]=ar[left]
         p=left
     Else
         ar[p]=ar[right]
         p=right

        left=2*p
        right=left+1
```

```
    if(left==n and last<ar[left])
        ar[p]=ar[left]
        p=left

    ar[p]=last
END OF FUNCTION delete

START OF FUNCTION heap_sort(int* ar,int n)
For i from 0 to n-1
    insert(ar, i, ar[i + 1])
End For
While(n>1)
    item=ar[1]
    delete(ar, n, item)
    n=n-1
    ar[n+1]=item
End While
END OF FUNCTION heap_sort

START OF MAIN FUNCTION
Input no. of elements n
For i from 0 to n-1
   Input ar[i]
heap_sort(ar,0,n-1)
For i from 0 to n-1
   Print ar[i]
END OF MAIN FUNCTION
```

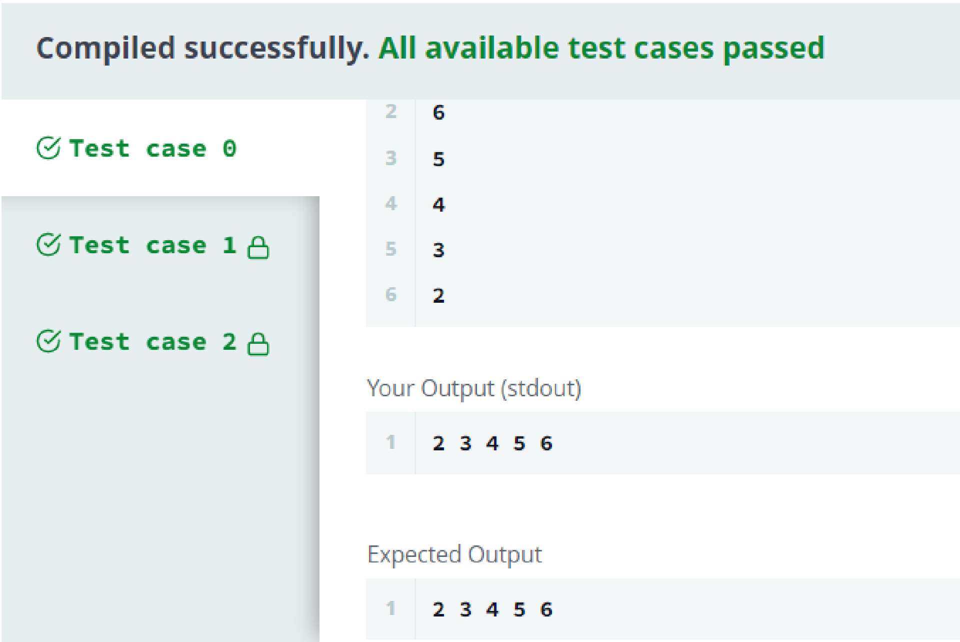
3.2.2 Code

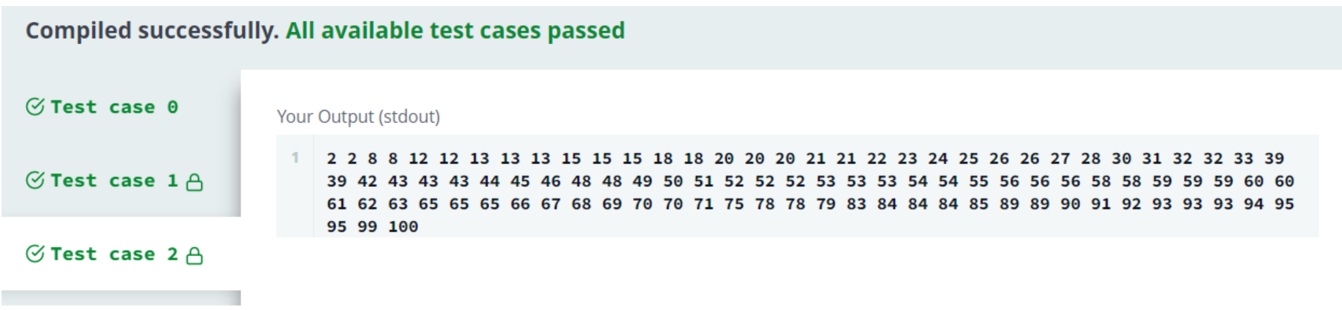
```c
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>

void insert(int* ar,int n,int item){
    n++;
    int p = n;
    while (p > 1) {
        int par = p / 2;
        if (item <= ar[par]) {
            ar[p] = item;
            return;
```

```
        }
        ar[p] = ar[par];
        p = par;
    }
    ar[1] = item;
}
void delete(int*ar,int n,int item){
    item=ar[1];
    int last=ar[n];
    n--;
    int p=1,left=2,right=3;
    while(right<=n){
        if(last>=ar[left] && last>=ar[right]){
            ar[p]=last;
            return;
        }
        if(ar[right]<=ar[left]){
            ar[p]=ar[left];
            p=left;
        }
        else{
            ar[p]=ar[right];
            p=right;
        }
        left=2*p;
        right=left+1;
    }
    if(left==n && last<ar[left]){
        ar[p]=ar[left];
        p=left;
    }
    ar[p]=last;
}
void heap_sort(int* ar,int n){
    for (int i = 0; i < n; i++)
        insert(ar, i, ar[i + 1]);
    int item;
    while(n>1){
        item=ar[1];
        delete(ar, n, item);
        n--;
        ar[n+1]=item;
    }
}

int main() {
    int n;
    scanf("%d",&n);
```

```c
    int *ar = (int*)malloc(sizeof(int)*n);

    for(int i = 1;i <=n; i++)
        scanf("%d",&ar[i]);

    heap_sort(ar,n);

    for(int i = 1; i <=n; i++)
        printf("%d ",ar[i]);
    return 0;
}
```

3.2.3 Sample output





3.3 Merge Sort

3.3.1 Algorithm

Algorithm 3.b :Merge Sort Algorithm

```
START OF FUNCTION merge(int* ar,int l,int mid,int r){
   Set i=l,j=mid+1,k=0
   While(i<=mid and j<=r)
        If(ar[i]<=ar[j])
             c[k]=ar[i]
             k=k+1
             i=i+1
        Else
            c[k]=ar[j]
            k=k+1
            j=j+1
        EndIf
   End While
   If(i>mid and j<=r)
        For m from j to r-1
            c[k]=ar[m]
            k=k+1
        End For
   Else If(i<=mid and j>r)
        For m from i to mid
          c[k]=ar[m]
          k=k+1
        End For
   EndIf
   For m from 0 to k
      ar[l]=c[m]
      l=l+1
   End For
END OF FUNCTION merge

START OF FUNCTION merge_sort(int* ar,int l,int r)
   If(l<r)
        mid=(l+r)/2
        merge_sort(ar,l, mid)
        merge_sort(ar,mid+1, r)
        merge(ar,l,mid,r)
   EndIf
END OF FUNCTION merge_sort

START OF MAIN FUNCTION
Input no. of elements n
For i from 0 to n-1
```

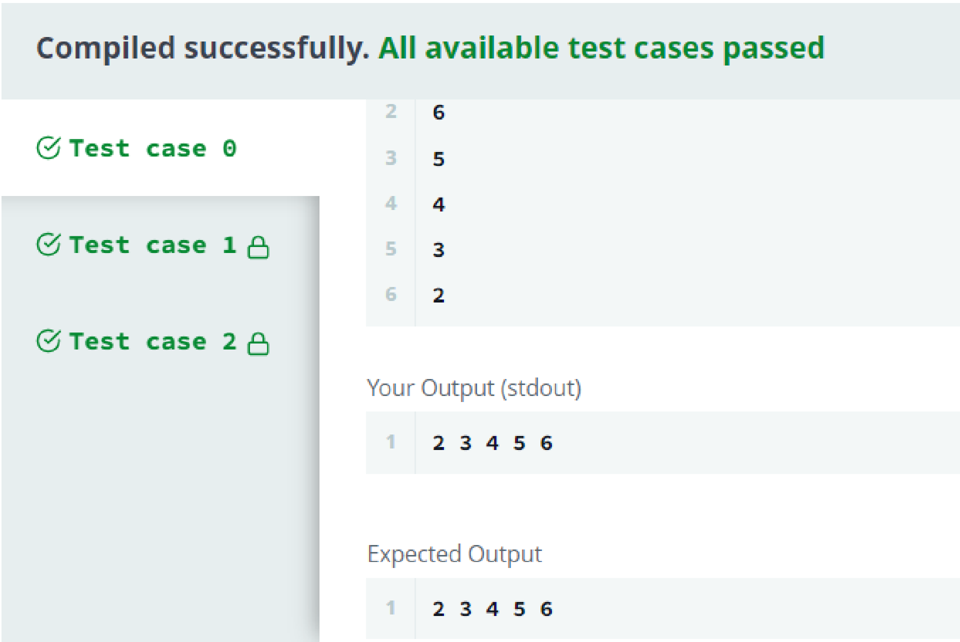
```
    Input ar[i]
  merge_sort(ar,0,n-1)
  For i from 0 to n-1
    Print ar[i]
END OF MAIN FUNCTION
```

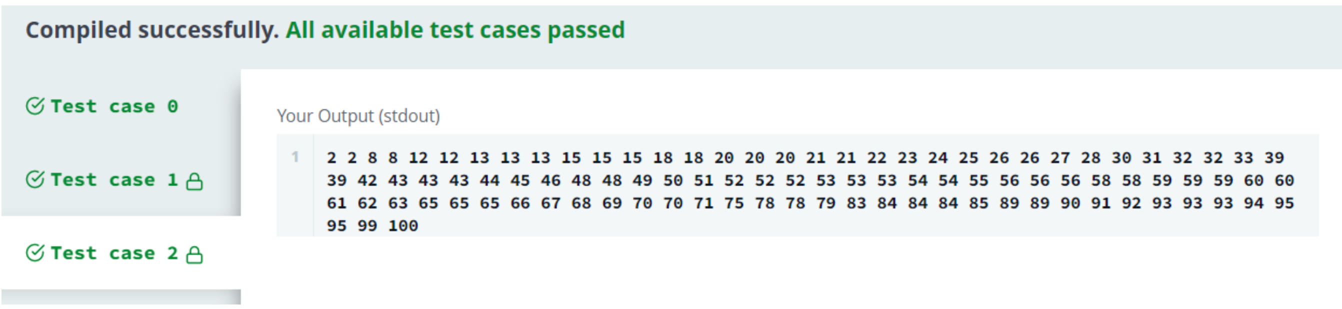
3.3.2 Code

```
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>

void merge(int* ar,int l,int mid,int r){
    int i=l,j=mid+1,k=0,c[r-l+1];
    while(i<=mid && j<=r){
        if(ar[i]<=ar[j])
            c[k++]=ar[i++];
        else
          c[k++]=ar[j++];
    }
    if(i>mid && j<=r){
        for(int m=j;m<=r;m++)
          c[k++]=ar[m];
    }
    else if(i<=mid && j>r){
        for(int m=i;m<=mid;m++)
          c[k++]=ar[m];
    }
    for(int m=0;m<k;m++)
      ar[l++]=c[m];
}

void merge_sort(int* ar,int l,int r){
    if(l<r){
        int mid=(l+r)/2;
        merge_sort(ar,l, mid);
        merge_sort(ar,mid+1, r);
        merge(ar,l,mid,r);
    }
}

int main() {
    int n;
```

```
    scanf("%d",&n);
    int *ar = (int*)malloc(sizeof(int)*n);

    for(int i = 0;i < n; i++)
        scanf("%d",&ar[i]);

    merge_sort(ar,0,n-1);

    for(int i = 0; i < n; i++)
        printf("%d ",ar[i]);
    return 0;
}
```

3.3.3 Sample output





3.4 Quick Sort

3.4.1 Algorithm

Algorithm 3.c :Quick Sort Algorithm

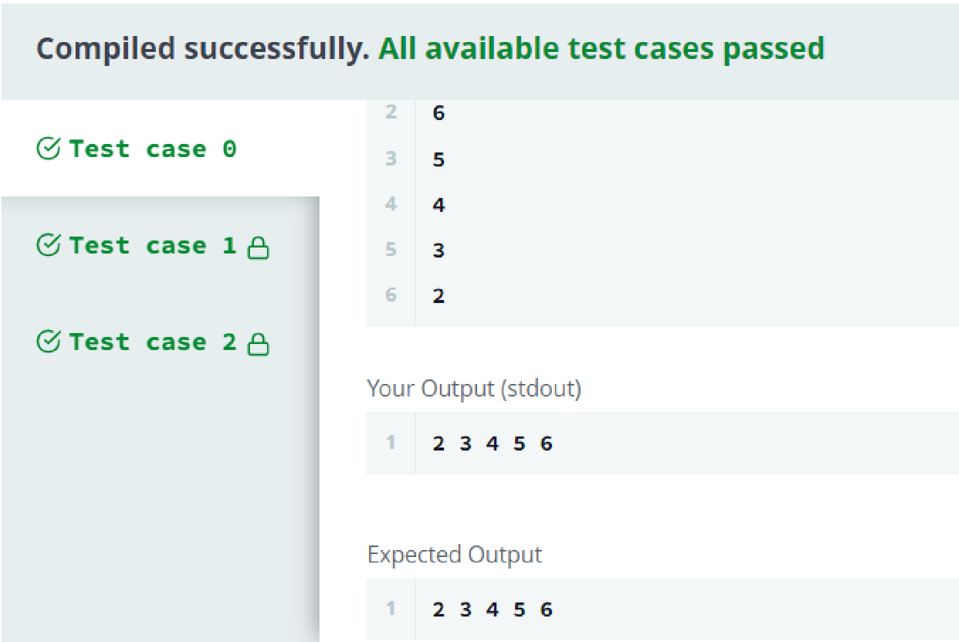
```
Declare structure stack s with array op[Max_size] and top as variables
START OF FUNCTION partition(int *ar,int left ,int right)
   loc=left
   While(left<right)
        While(ar[loc]<=ar[right] and loc<right )
             right=right-1
        End While
        If(ar[loc]>ar[right])
             temp=ar[loc]
             ar[loc]=ar[right]
             ar[right]=temp
             loc=right
        End If
        While(ar[loc]>=ar[left] and loc>left )
             left=left+1
        End While
        If(ar[loc]<ar[left])
             temp=ar[loc]
             ar[loc]=ar[left]
             ar[left]=temp
             loc=left
        EndIf
   End While
   return loc
END OF FUNCTION partition

START OF FUNCTION quick_sort(int* ar,int first,int n){
   If(first<n)
        int loc=partition(ar,first,n)
        quick_sort(ar,first,loc-1)
        quick_sort(ar, loc+1,n)
   EndIf
END OF FUNCTION quick_sort

START OF MAIN FUNCTION
Input no. of elements n
For i from 0 to n-1
   Input ar[i]
quick_sort(ar,0,n-1)
For i from 0 to n-1
   Print ar[i]
END OF MAIN FUNCTION
```

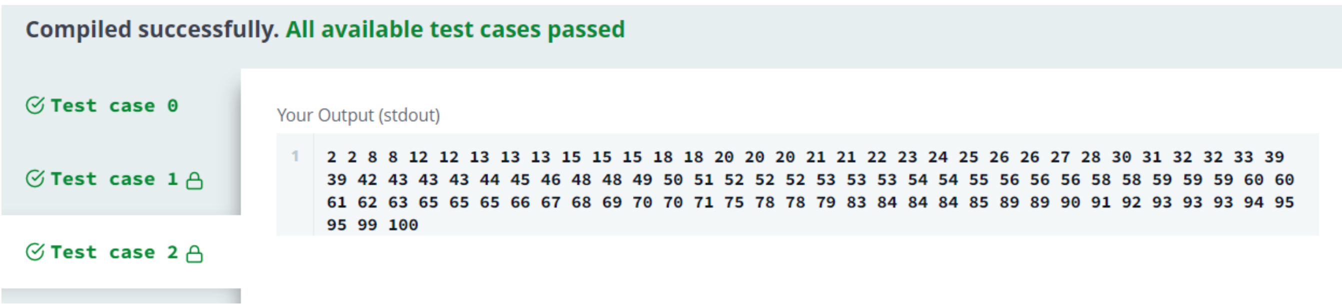
3.4.2 Code

```
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>

int partition(int *ar,int left ,int right){
    int loc=left;
    while(left<right){
        while(ar[loc]<=ar[right] && loc<right ){
            right--;
        }
        if(ar[loc]>ar[right]){
            int temp=ar[loc];
            ar[loc]=ar[right];
            ar[right]=temp;
            loc=right;
        }
        while(ar[loc]>=ar[left] && loc>left ){
            left++;
        }
        if(ar[loc]<ar[left]){
            int temp=ar[loc];
            ar[loc]=ar[left];
            ar[left]=temp;
            loc=left;
        }
    }
    return loc;
}

void quick_sort(int* ar,int first ,int n){
    if(first<n){
        int loc=partition(ar,first,n);
        quick_sort(ar,first,loc-1);
        quick_sort(ar, loc+1,n);
    }
}

int main() {
    int n;
    scanf("%d",&n);
    int *ar = (int*)malloc(sizeof(int)*n);
```

```
    for(int i = 0;i < n; i++)
        scanf("%d",&ar[i]);

    quick_sort(ar,0,n-1);

    for(int i = 0; i < n; i++)
        printf("%d ",ar[i]);
    return 0;
}
```

3.4.3 Sample output





3.5 Result

Program submitted and executed successfully in HackerRank Platform via user id aishwaryaaj2002

4 Hash Table using Chaining Method

4.1 Problem

Implement a Hash table using the Chaining method. Let the size of the hash table be 10 so that the index varies from 0 to 9.

4.2 Algorithm

Algorithm 4:Hash Table using Chaining Method

```
Table is a self-referential structure with value and Table*link as members
HashTable t is an array of Table h with size =10

START OF FUNCTION hashingFunction(int value)
return value%10
END OF FUNCTION hashingFunction

START OF FUNCTION insert_to_table(HashTable * t,int value)
k=hashingFunction(value)
If(t->h[k]==NULL)
     Allocate memory for t->h[k]
     t->h[k]->value=k
EndIf
ptr=t->h[k]
Allocate memory for node
node->value=value
node->link=NULL
While(ptr->link!=NULL)
      ptr=ptr->link
End While
ptr->link=node
END OF FUNCTION insert_to_table

START OF FUNCTION print_table(HashTable * t)
Set flag=0
For i from 0 to size-1
    If(t->h[i])
        flag=1
        ptr=t->h[i]
        Print i ->
        While(ptr->link!=NULL)
             Print ptr->link->value
             ptr=ptr->link
        End While
        Print "\n"
    EndIf
End For
If(flag==0)
```

```
    Print "Hashtable Empty !"
End If
END OF FUNCTION print_table

START OF FUNCTION does_exist(HashTable * t, int value)
k=hashingFunction(value)
If(t->h[k])
   ptr=t->h[k]->link
       While(ptr!=NULL)
           If(ptr->value==value)
              return 1
           EndIf
           ptr=ptr->link
       End While
EndIf
return 0
END OF FUNCTION does_exist

START OF MAIN FUNCTION
Allocate memory for hashtable t
While(1)
  Input choice
  Switch(choice)
      Case1 : Input value
              insert_to_table(t,value)
              break
      Case 2: Input value
              exists = does_exist(t,value)
              Print exists
              break
      Case 3: print_table(t)
              break
      Case 4: return 0
  End Switch-Case
End While
END OF MAIN FUNCTION
```

4.3 Code

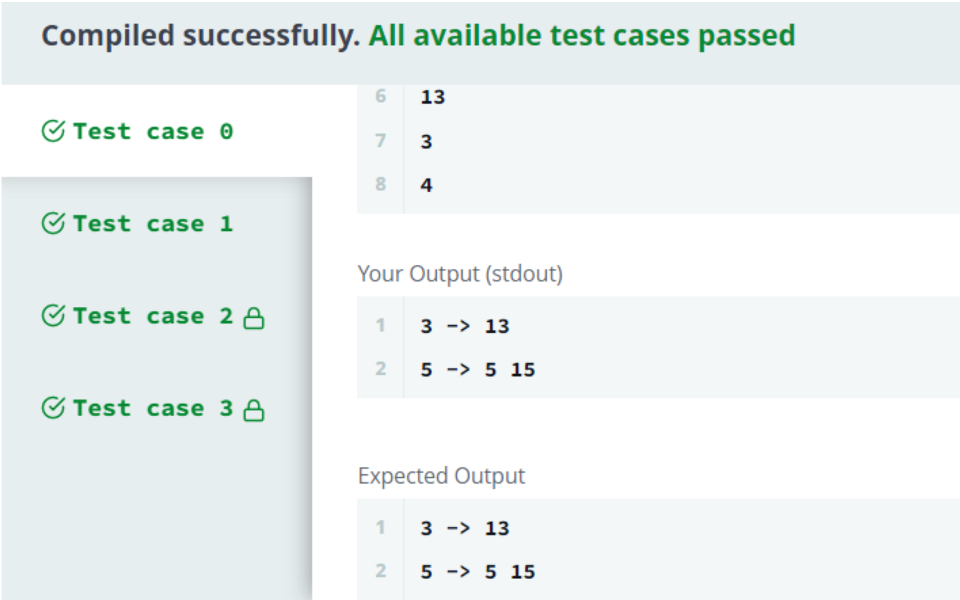
```
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>
```

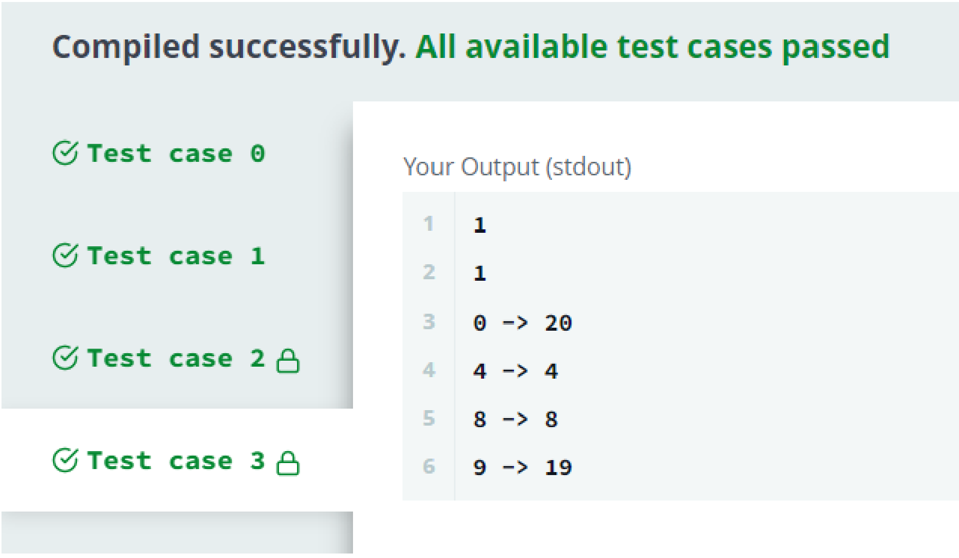
```
typedef struct Table
{
   int value;
   struct Table *link;
}Table;

typedef struct HashTable
{
   Table *h[10];
}HashTable;

int hashingFunction(int value)
{
    return value%10;
}

void insert_to_table(HashTable * t,int value)
{
    int k=hashingFunction(value);
    if(t->h[k]==NULL){
        t->h[k]=(Table *)malloc(sizeof(Table));
        t->h[k]->value=k;
    }
    Table *ptr=t->h[k];
    Table *node=(Table*)malloc(sizeof(Table));
    node->value=value;
    node->link=NULL;
    while(ptr->link!=NULL)
       ptr=ptr->link;
    ptr->link=node;
}

void print_table(HashTable * t)
{
    int i,flag=0;
    for(i=0;i<10;i++){
        if(t->h[i]){
            flag=1;
            Table *ptr=t->h[i];
            printf("%d ->",i);
            while(ptr->link){
               printf(" %d",ptr->link->value);
               ptr=ptr->link;
            }
            printf("\n");
        }
    }
```

```
    if(flag==0)
      printf("Hashtable Empty !\n");
}

int does_exist(HashTable * t, int value)
{
    int k=hashingFunction(value);
    if(t->h[k]){
        Table *ptr=t->h[k]->link;
            while(ptr){
              if(ptr->value==value)
                return 1;
              ptr=ptr->link;
            }
    }
    return 0;
}

int main() {
    HashTable * t = (HashTable *)malloc(sizeof(HashTable));
    while(1)
    {
        int choice;
        scanf("%d",&choice);
        switch(choice)
        {
            case 1:
            {
                int value;
                scanf("%d",&value);
                insert_to_table(t,value);
            }
            break;

            case 2:
            {
                int value;
                scanf("%d",&value);
                int exists = does_exist(t,value);
                printf("%d\n",exists);
            }
            break;

            case 3:
            {
                print_table(t);
            }
            break;
```

```
            case 4:
            {
                return 0;
            }
        }
    }
    return 0;
}
```

4.4 Sample output





4.5 Result

Program submitted and executed successfully in HackerRank Platform via user id aishwaryaaj2002

5 Hash table using Linear Probing

5.1 Problem

Implement a Hash table that uses Linear Probing for collision resolution.

5.2 Algorithm

Algorithm 5:Hash table using Linear Probing algorithm

```
Declare HashTable ht,an array with SIZE=10
START OF FUNCTION hash(int val)
return value%10
END OF FUNCTION hash

START OF FUNCTION insert(HashTable ht,int val){
k=hash(val)
i=k
Do While(i!=k)
     If(ht[i]==0)
        ht[i]=val
        return
     EndIf
     i=(i+1) mod SIZE
End Do While
END OF FUNCTION insert

START OF FUNCTION print(HashTable ht)
For i from 0 to SIZE-1
     Print i,ht[i]
END OF FUNCTION print

START OF FUNCTION doesExist(HashTable ht,int val){
k=hash(val)
Set i=k
Do While(i!=k)
     If(ht[i]==val)
         return 1
     EndIf
     i=(i+1) mod SIZE
End Do While
return 0
END OF FUNCTION doesExist

START OF MAIN FUNCTION
Allocate memory for hashtable ht
While(1)
  Input opt
  Switch(opt)
```

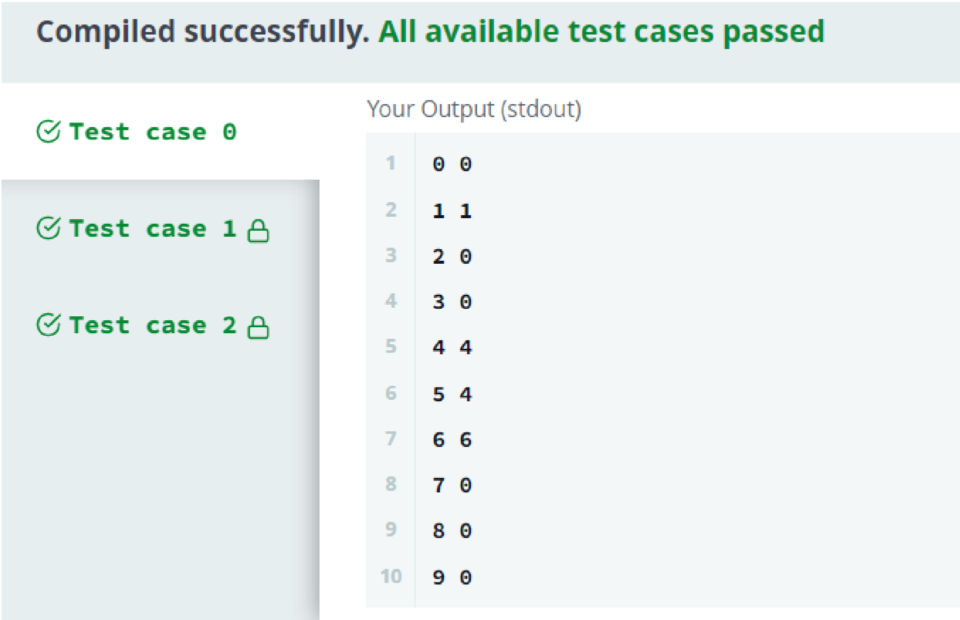
```
        Case1 : Input val
                insert(ht,val)
                break
        Case 2: Input val
                exists = doesExist(ht,val)
                If(exists=1)
                   Print "Exists"
                Else
                    Print "Doesn't Exist"
                EndIf
                break
        Case 3: print(ht)
                break
        Case 4: return 0
    End Switch-Case
  End While
  END OF MAIN FUNCTION
```

5.3 Code

```c
#include <math.h>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <assert.h>
#include <limits.h>
#include <stdbool.h>

#define SIZE 10
typedef int* HashTable;

int hash(int val){
    return val%SIZE;
}

void insert(HashTable ht,int val){
    int k=hash(val);
    int i=k;
    do {
        if(ht[i]==0){
            ht[i]=val;
            return;
        }
        i=(i+1)%SIZE;
    }while (i!=k);
}
```

```c
int doesExist(HashTable ht,int val){
    int k=hash(val), i=k;
    do {
        if(ht[i]==val){
            return 1;
        }
        i=(i+1)%SIZE;
    }while (i!=k);
    return 0;
}

void print(HashTable ht){
      for(int i=0;i<SIZE;i++)
          printf("%d %d\n",i,ht[i]);
}

int main(){
    HashTable ht = (int*)malloc(sizeof(int)*SIZE);
    int opt,val,exists;

    do{
        scanf("%d",&opt);
        switch(opt){
            case 1: scanf("%d",&val);
                    insert(ht,val);
                    break;
            case 2: scanf("%d",&val);
                    exists = doesExist(ht,val);
                    if(exists)
                        printf("Exists\n");
                    else
                        printf("Doesn't Exist\n");
                    break;
            case 3: print(ht);
                    break;
        }

    }while(opt != 4);
    return 0;
}
```

5.4 Sample output



5.5 Result

Program submitted and executed successfully in HackerRank Platform via user id aishwaryaaj2002