BRCM CET, BAHAL

LAB MANUAL

Data Structures & Algorithms LAB Using C (LC-CSE-213G)

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Check list for Lab Manual

Sr. No.	Particulars
1	Mission and Vision
2	Course Outcomes
3	Guidelines for the student
4	List of Programs as per University
5	Sample copy of File

Department of Computer Science & Engineering

Vision and Mission of the Department

Vision

To be a Model in Quality Education for producing highly talented and globally recognizable students with sound ethics, latest knowledge, and innovative ideas in Computer Science & Engineering.

MISSION

To be a Model in Quality Education by

M1: Imparting good sound theoretical basis and wide-ranging practical experience to the Students for fulfilling the upcoming needs of the Society in the various fields of Computer Science & Engineering.

M2: Offering the Students an overall background suitable for making a Successful career in Industry/Research/Higher Education in India and abroad.

M3: Providing opportunity to the Students for Learning beyond Curriculum and improving Communication Skills.

M4: Engaging Students in Learning, Understanding and Applying Novel Ideas.

Course: Data Structures & Algorithms LAB Using C
Course Code: LC-CSE-213G

CO (Course Outcomes)		**RBT*- Revised Bloom's Taxonomy**
CO1	To **Choose** appropriate data structure while designing the applications.	L2 (Understand)
CO2	To **Solve** the problems of various data structures such as stack, queue and tree.	L2 (Understand)
CO3	To **Analyze** the complexity of the algorithms.	L4 (Analyze)
CO4	To **Implement** various searching and sorting techniques.	L6 (Create)
CO5	To **Implement** linear and non-linear data structures using linked list	L6 (Create)

CO PO-PSO Articulation Matrices

Course Outcomes (COs)	**(POs)**												**PSOs**	
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3											1	2	3
CO2	2	3			2							1	2	2
CO3	2	2	3		2							1	2	2
CO4	2		3		2							1	3	2
CO5	2	2	3	1	2							1	3	2

INDEX

Ex. No. 1a ARRAY IMPLEMENTATION OF STACK

Date:

Aim: To implement stack operations using array.

Algorithm

```
1. Start
2. Define a array stack of size max = 5
3. Initialize top = -1
4. Display a menu listing stack operations
5. Accept choice
6. If choice = 1 then
7. If top < max -1
8. Increment top
9. Store element at current position of top
10. Else
11. Print Stack overflow
12. If choice = 2 then
13. If top < 0 then
14. Print Stack underflow
15. Else
16. Display current top element
17. Decrement top
18. If choice = 3 then
19. Display stack elements starting from top
20. Stop
```

Program

```
/* 1a - Stack Operation using Arrays */
#include <stdio.h>
#include <conio.h>
#define max 5
static int stack[max];
int top = -1;
void push(int x)
{
	stack[++top] = x;
}
int pop()
{
	return (stack[top--]);
}
void view()
{
	int i;
	if (top < 0)
		printf("\n Stack Empty \n");
	else
	{
		printf("\n Top-->");
		for(i=top; i>=0; i--)
		{
			printf("%4d", stack[i]);
		}
		printf("\n");
	}
}
main()
{
	int ch=0, val;
	clrscr();
	while(ch != 4)
	{
		printf("\n STACK OPERATION \n");
		printf("1.PUSH ");
		printf("2.POP ");
		printf("3.VIEW ");
		printf("4.QUIT \n");
		printf("Enter Choice : ");
		scanf("%d", &ch);
		switch(ch)
		{
		  case 1:
			if(top < max-1)
			{
				printf("\nEnter Stack element : ");
				scanf("%d", &val);
				push(val);
			}
			else
				printf("\n Stack Overflow \n");
			break;
		case 2:

			if(top < 0)
				printf("\n Stack Underflow \n");
			else
			{
				val = pop();
				printf("\n Popped element is %d\n", val);
			}
			break;
		case 3:
			view();
			break;
		case 4:
```

```
                    exit(0);
                    default:
            printf("\n Invalid Choice \n");
            }
    }
}
```

Output

```
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 1
Enter Stack element : 12
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 1
Enter Stack element : 23
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 1
Enter Stack element : 34
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 1
Enter Stack element : 45
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 3
Top--> 45 34 23 12
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 2
Popped element is 45
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 3
Top--> 34 23 12
STACK OPERATION
1.PUSH 2.POP 3.VIEW 4.QUIT
Enter Choice : 4
```

Result: Thus push and pop operations of a stack was demonstrated using arrays.

Ex. No. 1b ARRAY IMPLEMENTATION OF QUEUE

Date:

Aim: To implement queue operations using array.

Algorithm

```
1. Start
2. Define a array queue of size max = 5
3. Initialize front = rear = –1
4. Display a menu listing queue operations
5. Accept choice
6. If choice = 1 then
7. If rear < max -1
8. Increment rear
9. Store element at current position of rear
10. Else
11. Print Queue Full
12. If choice = 2 then
13. If front = –1 then
14. Print Queue empty
15. Else
16. Display current front element
17. Increment front
18. If choice = 3 then
19. Display queue elements starting from front to rear.
20. Stop
```

Program

```c
/* 1b - Queue Operation using Arrays */
#include <stdio.h>
#include <conio.h>
#define max 5
static int queue[max];
int front = -1;
int rear = -1;
void insert(int x)
{
	queue[++rear] = x;
	if (front == -1)
	front = 0;
}
int remove()
{
        int val;
        val = queue[front];
        if (front==rear && rear==max-1)
                front = rear = -1;
        else
                front ++;
                return (val);
}

void view()
{
        int i;
        if (front == -1)
                printf("\n Queue Empty \n");
        else
        {
                printf("\n Front-->");
                for(i=front; i<=rear; i++)
                printf("%4d", queue[i]);
                printf(" <--Rear\n");
        }
}
main()
{

        int ch= 0,val;
        clrscr();
        while(ch != 4)
        {
                printf("\n QUEUE OPERATION \n");
                printf("1.INSERT ");
                printf("2.DELETE ");
                printf("3.VIEW ");
                printf("4.QUIT\n");
                printf("Enter Choice : ");
                scanf("%d", &ch);
                switch(ch)
                {
                case 1:
                        if(rear < max-1)
                        {
                                printf("\n Enter element to be inserted : ");
                                scanf("%d", &val);
                                insert(val);
                        }
                        else
                                printf("\n Queue Full \n");
                        break;
                case 2:
```

```
                        if(front == -1)
                                printf("\n Queue Empty \n");
                        else
```

```
                    {
                              val = remove();
                              printf("\n Element deleted : %d \n", val);
                    }
                    break;
          case 3:
                    view();
                    break;
          case 4:
                    exit(0);

          default:
                    printf("\n Invalid Choice \n");
          }
     }
}
```

Output

```
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Enter element to be inserted : 12
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Enter element to be inserted : 23
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Enter element to be inserted : 34
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Enter element to be inserted : 45
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Enter element to be inserted : 56
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 1
Queue Full
QUEUE OPERATION
1.INSERT 2.DELETE 3.VIEW 4.QUIT
Enter Choice : 3
Front--> 12 23 34 45 56 <--Rear
```

Result: Thus insert and delete operations of a queue was demonstrated using arrays.

Ex. 2 ARRAY IMPLEMENTATION OF LIST

Date:

Aim: To create a list using array and perform operations such as display, insertions and deletions.

Algorithm

```
1. Start
2. Define list using an array of size n.
3. First item with subscript or position = 0
4. Display menu on list operation
5. Accept user choice
6. If choice = 1 then
7. Locate node after which insertion is to be done
8. Create an empty location in array after the node by moving the existing elements one
   position ahead.
9. Insert the new element at appropriate position
10. Else if choice = 2
11. Get element to be deleted.
12. Locate the position of the element replace the element with the element in the
    following position.
13. Repeat the step for successive elements until end of the array.
14. Else
15. Traverse the list from position or subscript 0 to n.
16. Stop
```

PROGRAM

```
#include<stdio.h>
#include<conio.h>
#define MAX 10

void create();
void insert();
void deletion();
void search();
void display();
int a,b[20], n, p, e, f, i, pos;

void main()
{
        //clrscr();
        int ch;
        char g='y';

        do
         {
                printf("\n main Menu");
                printf("\n  1.Create  \n  2.Delete  \n  3.Search  \n  4.Insert  \n  5.Display\n  6.Exit
        \n");
                printf("\n Enter your Choice");
                scanf("%d", &ch);
                switch(ch)
                {
                  case 1:
                        create();
                        break;
                 case 2:
                        deletion();
                        break;
                 case 3:
                        search();
                        break;
                case 4:
                        insert();
                        break;
                case 5:
                        display();
                        break;
                case 6:
                        exit();
                        break;
                default:
                        printf("\n Enter the correct choice:");
              }
         printf("\n Do u want to continue:::");
          scanf("\n%c", &g);
        }
        while(g=='y'||g=='Y');
        getch();
}


void create()
{
        printf("\n Enter the number of nodes");
        scanf("%d", &n);
        for(i=0;i<n;i++)
        {
                printf("\n Enter the Element:",i+1);
                scanf("%d", &b[i]);
        }

}

void deletion()
{
        printf("\n Enter the position u want to delete::");
        scanf("%d", &pos);
        if(pos>=n)
        {
                printf("\n Invalid Location::");
        }
        else
        {
                for(i=pos+1;i<n;i++)
                {
                        b[i-1]=b[i];
                }
                n--;
        }

        printf("\n The Elements after deletion");
        for(i=0;i<n;i++)
        {
                printf("\t%d", b[i]);
        }
}


void search()
{
        printf("\n Enter the Element to be searched:");
        scanf("%d", &e);
        for(i=0;i<n;i++)
        {
                if(b[i]==e)
                {
                        printf("Value is in the %d Position", i);
                }
                else
                {
                        printf("Value %d is not in the list::", e);
                        continue;
                }
        }
}



void insert()
{
        printf("\n Enter the position u need to insert::");
        scanf("%d", &pos);

        if(pos>=n)
        {
                 printf("\n invalid Location::");
         }
```

```
            else
            {
                        for(i=MAX-1;i>=pos-1;i--)
                        {
                                    b[i+1]=b[i];
                        }
                        printf("\n Enter the element to insert::\n");
                        scanf("%d",&p);
                        b[pos]=p;
                        n++;
             }
            printf("\n The list after insertion::\n");
           display();
}


void display()
{
           printf("\n The Elements of The list ADT are:");
           for(i=0;i<n;i++)
           {
                       printf("\n\n%d", b[i]);
           }
}
```

Output

```
Array of 10 numbers:
Input elements:
1
2
4
5
6
7
8
9
10
11
Current array: 1 2 4 5 6 7 8 9 10 11
Would you like to enter another element? [1/0]: 1
Input element: 3
Input position: 2
Current array: 1 2 3 4 5 6 7 8 9 10
```

Result: Thus the array implementation of list was demonstrated.

EX. 3a LINKED LIST IMPLEMENTATION OF LIST [SINGLY LINKED LIST]
Date:

Aim: To define a singly linked list node and perform operations such as insertions and deletions dynamically.

Algorithm

```
1. Start
2. Define single linked list node as self referential structure
3. Create Head node with label = -1 and next = NULL using
4. Display menu on list operation
5. Accept user choice
6. If choice = 1 then
7. Locate node after which insertion is to be done
8. Create a new node and get data part
9. Insert the new node at appropriate position by manipulating address
10. Else if choice = 2
11. Get node's data to be deleted.
12. Locate the node and delink the node
13. Rearrange the links
14. Else
15. Traverse the list from Head node to node which points to null
16. Stop
```

Program

```
/* 3c - Single Linked List */
#include <stdio.h>
#include <conio.h>
#include <process.h>
#include <alloc.h>
#include <string.h>
struct node
{
        int label;
        struct node *next;
};
main()
{

  int ch, fou=0;
  int k;
  struct node *h, *temp, *head, *h1;
  /* Head node construction */
  head = (struct node*) malloc(sizeof(struct node));
  head->label = -1;
  head->next = NULL;
  while(-1)
  {
    clrscr();
```

```
printf("\n\n SINGLY LINKED LIST OPERATIONS \n");
printf("1->Add ");
printf("2->Delete ");
printf("3->View ");
printf("4->Exit \n");
printf("Enter your choice : ");
scanf("%d",  &ch);
switch(ch)
{
      /* Add a node at any intermediate location */
      case 1:
           printf("\n Enter label after which to add : ");
           scanf("%d", &k);
           h = head;
           fou = 0;
           if (h->label == k)
           fou = 1;
           while(h->next != NULL)
          {
              if (h->label == k)
             {
                 fou=1;
                 break;
              }
                h = h->next;
           }
          if (h->label == k)
               fou = 1;
           if (fou != 1)
                printf("Node not found\n");
          else
          {
             temp=(struct node *)(malloc(sizeof(struct node)));
              printf("Enter label for new node : ");
              scanf("%d" , &temp->label);
              temp->next = h->next;
              h->next = temp;
           }
           break;

      /* Delete any intermediate node */
      case 2:
          printf("Enter label of node to be deleted\n");
          scanf("%d", &k);
          fou = 0;
           h = h1 = head;
          while (h->next != NULL)
          {
                  h = h->next;
                  if (h->label == k)
                  {
                          fou = 1;
                          break;
                  }
          }
          if (fou == 0)
                  printf("Sorry Node not found\n");
          else
         {
                  while (h1->next != h)
                  h1 = h1->next;
                  h1->next = h->next;
                  free(h);
                  printf("Node deleted successfully \n");
          }

          break;

      case 3:
                  printf("\n\n HEAD -> ");
                  h=head;
                  while (h->next != NULL)
                  {
                     h = h->next;
                     printf("%d -> ",h->label);
                  }
                  printf("NULL");
                  break;
      case 4:
                  exit(0);
      }
}
}
```

Output

```
SINGLY LINKED LIST OPERATIONS
1->Add 2->Delete 3->View 4->Exit
Enter your choice : 1
Enter label after which new node is to be added : -1
Enter label for new node : 23
SINGLY LINKED LIST OPERATIONS
1->Add 2->Delete 3->View 4->Exit
Enter your choice : 1
Enter label after which new node is to be added : 23
Enter label for new node : 67
SINGLY LINKED LIST OPERATIONS
1->Add 2->Delete 3->View 4->Exit
Enter your choice : 3
HEAD -> 23 -> 67 -> NULL
```

Result: Thus operation on single linked list is performed.

Ex. No. 3b LINKED LIST IMPLEMENTATION OF STACK

Date:

Aim: To implement stack operations using linked list.

Algorithm

1. Start
2. Define a singly linked list node for stack
3. Create Head node
4. Display a menu listing stack operations
5. Accept choice
6. If choice = 1 then
7. Create a new node with data
8. Make new node point to first node
9. Make head node point to new node
10. If choice = 2 then
11. Make temp node point to first node
12. Make head node point to next of temp node
13. Release memory
14. If choice = 3 then
15. Display stack elements starting from head node till null
16. Stop

Program

```
/* 5c - Stack using Single Linked List */
#include <stdio.h>
#include <conio.h>
#include <process.h>
#include <alloc.h>
struct node
{
        int label;
        struct node *next;
};
main()
{
        int ch = 0;
        int k;
        struct node *h, *temp, *head;
        /* Head node construction */
        head = (struct node*) malloc(sizeof(struct node));
        head->next = NULL;
        while(1)
        {
                printf("\n Stack using Linked List \n");
                printf("1->Push ");
```

```
                    printf("2->Pop ");
                    printf("3->View ");
                    printf("4->Exit \n");
                    printf("Enter your choice : ");
                    scanf("%d",  &ch);
                    switch(ch)
                    {
                    case 1:
                         /* Create a new node */
                         temp=(struct node *)(malloc(sizeof(struct node)));
                         printf("Enter label for new node : ");
                         scanf("%d", &temp->label);
                         h = head;
                         temp->next = h->next;
                         h->next = temp;
                         break;
                    case 2:
                         /* Delink the first node */
                         h = head->next;
                         head->next = h->next;
                         printf("Node %s deleted\n", h->label);
                         free(h);
                         break;
                    case 3:
                         printf("\n HEAD -> ");
                         h = head;
                         /* Loop till last node */
                         while(h->next != NULL)
                         {
                              h = h->next;
                              printf("%d -> ",h->label);
                         }
                         printf("NULL \n");
                         break;
                    case 4:
                         exit(0);
               }
          }
}
```

Output

```
Stack using Linked List
1->Push 2->Pop 3->View 4->Exit

Enter your choice : 1
Enter label for new node : 23
New node added
Stack using Linked List
1->Push 2->Pop 3->View 4->Exit
```

```
Enter your choice : 1
Enter label for new node : 34
Stack using Linked List
1->Push 2->Pop 3->View 4->Exit

Enter your choice : 3
HEAD -> 34 -> 23 -> NULL
```

Result: Thus push and pop operations of a stack was demonstrated using linked list.

Ex. No. 3c LINKED LIST IMPLEMENTATION OF QUEUE
Date:

Aim: To implement queue operations using linked list.

Algorithm

```
1. Start
2. Define a singly linked list node for stack
3. Create Head node
4. Display a menu listing stack operations
5. Accept choice
6. If choice = 1 then
7. Create a new node with data
8. Make new node point to first node
9. Make head node point to new node
10. If choice = 2 then
11. Make temp node point to first node
12. Make head node point to next of temp node
13. Release memory
14. If choice = 3 then
15. Display stack elements starting from head node till null
16. Stop
```

Program

```
/* 3c - Queue using Single Linked List */
#include <stdio.h>
#include <conio.h>
#include <process.h>
#include <alloc.h>
struct node
{
	int label;
	struct node *next;
};
main()
{
	int ch=0;
	int k;
	struct node *h, *temp, *head;
	/* Head node construction */
	head = (struct node*) malloc(sizeof(struct node));
	head->next = NULL;
	while(1)
	{
		printf("\n Queue using Linked List \n");
		printf("1->Insert ");
		printf("2->Delete ");
		printf("3->View ");
```

```
        printf("4->Exit \n");
        printf("Enter your choice : ");
        scanf("%d",  &ch);
        switch(ch)
        {
        case 1:
            /* Create a new node */
            temp=(struct node *)(malloc(sizeof(struct node)));
            printf("Enter label for new node : ");
            scanf("%d", &temp->label);
            /* Reorganize the links */
            h = head;
            while (h->next != NULL)
                h = h->next;
            h->next = temp;
            temp->next = NULL;
            break;

        case 2:
            /* Delink the first node */
            h = head->next;
            head->next = h->next;
            printf("Node deleted \n");
            free(h);
            break;
        case 3:
            printf("\n\nHEAD -> ");
            h=head;
            while (h->next!=NULL)
            {
                h = h->next;
                printf("%d -> ",h->label);
            }
            printf("NULL \n");
            break;
        case 4:
            exit(0);
        }
    }
}
```

Output

```
Queue using Linked List
1->Insert 2->Delete 3->View 4->Exit
Enter your choice : 1
Enter label for new node : 12
Queue using Linked List
1->Insert 2->Delete 3->View 4->Exit
Enter your choice : 1
Enter label for new node : 23
Queue using Linked List
1->Insert 2->Delete 3->View 4->Exit
Enter your choice : 3
HEAD -> 12 -> 23 -> NULL
```

Result: Thus push and pop operations of a stack was demonstrated using linked list.

Ex. No. 4a **APPLICATIONS OF LIST**

POLYNOMIAL ADDITION AND SUBTRACTION

Date:

Aim: To store a polynomial using linked list. Also, perform addition and subtraction on two polynomials.

Algorithm

```
Let p and q be the two polynomials represented by linked lists
1. while p and q are not null, repeat step 2.
2. If powers of the two terms are equal then
        If the terms do not cancel then
                Insert the sum of the terms into the sum Polynomial
                Advance p Advance q
        Else if the power of the first polynomial> power of second Then
                Insert the term from first polynomial into sum polynomial
                Advance p
        Else
                insert the term from second polynomial into sum polynomial Advance q
3. Copy the remaining terms from the non empty polynomial into the sum polynomial.
```

The third step of the algorithm is to be processed till the end of the polynomials has not been reached.

Program

```
/* 4a – Polynomial Addition and Subtraction */

#include <stdio.h>
#include <conio.h>
#include <malloc.h>
struct node
{
        int num;
         int coeff;
        struct node *next;
};
struct node *start1 = NULL;
struct node *start2 = NULL;
struct node *start3 = NULL;
struct node *start4 = NULL;
struct node *last3 = NULL;
struct node *create_poly(struct node *);
struct node *display_poly(struct node *);
struct node *add_poly(struct node *, struct node *, struct node *);
struct node *sub_poly(struct node *, struct node *, struct node *);
struct node *add_node(struct node *, int, int);
int main()
{
  int option;
 clrscr();
 do
 {
     printf("\n******* MAIN MENU *******");
     printf("\n 1. Enter the □rst polynomial");
     printf("\n 2. Display the □rst polynomial");
     printf("\n 3. Enter the second polynomial");
     printf("\n 4. Display the second polynomial");
     printf("\n 5. Add the polynomials");
     printf("\n 6. Display the result");
     printf("\n 7. Subtract the polynomials");
     printf("\n 8. Display the result");
     printf("\n 9. EXIT");
     printf("\n\n Enter your option : ");
     scanf("%d", &option);
     switch(option)
      {
        case 1:
           start1 = create_poly(start1);
           break;
        case 2:
           start1 = display_poly(start1);
           break;
        case 3:
           start2 = create_poly(start2);
           break;
        case 4:
           start2 = display_poly(start2);
           break;
        case 5:
           start3 = add_poly(start1, start2, start3);
           break;
        case 6:
           start3 = display_poly(start3);
           break;
        case 7:
           start4 = sub_poly(start1, start2, start4);
           break;
        case 8:
           start4 = display_poly(start4);
           break;
       }
 }while(option!=9);
 getch();
 return 0;
}

struct node *create_poly(struct node *start)
{
           struct node *new_node, *ptr;
           int n, c;
           printf("\n Enter the number : ");
           scanf("%d", &n);
           printf("\t Enter its coefﬁcient : ");
            scanf("%d", &c);
           while(n != –1)
           {
                if(start==NULL)
               {
                   new_node = (struct node *)malloc(sizeof(struct node));
                    new_node ->num = n;
                   new_node ->coeff = c;
                   new_node ->next = NULL;
                   start = new_node;
               }
               else
               {
                    ptr = start;
                   while(ptr ->next != NULL) ptr = ptr ->next;
                   new_node = (struct node *)malloc(sizeof(struct node));
                   new_node ->num = n;
                   new_node ->coeff = c;
                   new_node ->next = NULL;
                   ptr ->next = new_node;
               }

               printf("\n Enter the number : ");
               scanf("%d", &n);
               if(n == –1)
                    break;
               printf("\t Enter its coefﬁcient : ");
                scanf("%d", &c);
           } return start;
}

struct node *display_poly(struct node *start)
{
           struct node *ptr;
           ptr = start;
           while(ptr != NULL)
           {
                printf("\n%d x %d\t", ptr ->num, ptr ->coeff);
               ptr = ptr ->next;
           }
            return start;
}

struct node *add_poly(struct node *start1, struct node *start2, struct node *start3)
{
           struct node *ptr1, *ptr2;
           int sum_num, c;
           ptr1 = start1, ptr2 = start2;
            while(ptr1 != NULL && ptr2 != NULL)
           {
                if(ptr1 ->coeff == ptr2 ->coeff)
               {
                   sum_num = ptr1 ->num + ptr2 ->num;
                   start3 = add_node(start3, sum_num, ptr1 ->coeff);
                   ptr1 = ptr1 ->next; ptr2 = ptr2 ->next;
               }
               else if(ptr1 ->coeff > ptr2 ->coeff)
               {
                    start3 = add_node(start3, ptr1 ->num, ptr1 ->coeff);
                   ptr1 = ptr1 ->next;
               }
               else if(ptr1 ->coeff < ptr2 ->coeff)
               {
                   start3 = add_node(start3, ptr2 ->num, ptr2 ->coeff);
                   ptr2 = ptr2 ->next;
               }
            }
            if(ptr1 == NULL)
           {
                while(ptr2 != NULL)
               {
                    start3 = add_node(start3, ptr2 ->num, ptr2 ->coeff);
                   ptr2 = ptr2 ->next;
               }
            }
            if(ptr2 == NULL)
           {
                while(ptr1 != NULL)
               {
                   start3 = add_node(start3, ptr1 ->num, ptr1 ->coeff);
                   ptr1 = ptr1 ->next;
               }
            }
        return start3;
}


struct node *sub_poly(struct node *start1, struct node *start2, struct node *start4)
{
            struct node *ptr1, *ptr2;
           int sub_num, c;
            ptr1 = start1, ptr2 = start2;
           do
           {
                if(ptr1 ->coeff == ptr2 ->coeff)
               {
                    sub_num = ptr1 ->num – ptr2 ->num;
```

```
                start4 = add_node(start4, sub_num, ptr1 ->coeff);
                ptr1 = ptr1 ->next; ptr2 = ptr2 ->next;
            }
            else if(ptr1 ->coeff > ptr2 ->coeff)
            {
                start4 = add_node(start4, ptr1 ->num, ptr1 ->coeff);
                ptr1 = ptr1 ->next;
            }
            else if(ptr1 ->coeff < ptr2 ->coeff)
            {
                start4 = add_node(start4, ptr2 ->num, ptr2 ->coeff);
                ptr2 = ptr2 ->next;
            }
        }while(ptr1 != NULL || ptr2 != NULL);
        if(ptr1 == NULL)
        {
            while(ptr2 != NULL)
            {
                start4 = add_node(start4, ptr2 ->num, ptr2 ->coeff);
                ptr2 = ptr2 ->next;
            }
        }
        if(ptr2 == NULL)
        {
            while(ptr1 != NULL)
            {
                start4 = add_node(start4, ptr1 ->num, ptr1 ->coeff);
                ptr1 = ptr1 ->next;
            }
        }
        return start4;
}

struct node *add_node(struct node *start, int n, int c)
{
        struct node *ptr, *new_node;
        if(start == NULL)
        {
            new_node = (struct node *)malloc(sizeof(struct node));
            new_node ->num = n;
            new_node ->coeff = c;
            new_node ->next = NULL;
            start = new_node;
        }
        else
        {
            ptr = start;
            while(ptr ->next != NULL)
                ptr = ptr ->next;
            new_node = (struct node *)malloc(sizeof(struct node));
```

```
                new_node ->num = n;
                new_node ->coeff = c;
                new_node ->next = NULL;
                ptr ->next = new_node;
        }
        return start;
}
```

Output

```
******* MAIN MENU *******
1. Enter the 1rst polynomial
2. Display the 1rst polynomial

9. EXIT
Enter your option : 1
Enter the number : 6
Enter its coefﬁcient : 2
Enter the number : 5
Enter its coefﬁcient : 1
Enter the number : –1
Enter your option : 2
6 x 2 5 x 1
Enter your option : 9
```

Result: Thus application of list for polynomial manipulation was demonstrated.

Ex. No. 4b **INFIX TO POSTFIX**
Date:

Aim: To convert infix expression to its postfix form using stack operations.

Algorithm

1. Start
2. Define a array *stack* of size *max* = 20
3. Initialize *top* = -1
4. Read the infix expression character-by-character
5. If character is an operand print it
6. If character is an operator
7. Compare the operator"s priority with the stack[top] operator.
8. If the stack [top] operator has higher or equal priority than the inputoperator, Pop it from the stack and print it.
9. Else
10. Push the input operator onto the stack
11. If character is a left parenthesis, then push it onto the stack.
12. If the character is a right parenthesis, pop all the operators from the stack andprint it until a left parenthesis is encountered. Do not print the parenthesis.

Program

```
/* 4b - Conversion of infix to postfix expression */
#include <stdio.h>
#include <conio.h>
#include <string.h>
#define MAX 20
int top = -1;
char stack[MAX];
char pop();
void push(char item);
int prcd(char symbol)
{
   switch(symbol)
   {
        case '+':
        case '-':
                return 2;
                break;
        case '*':
        case '/':
                return 4;
                break;
        case '^':
        case '$':
                return 6;
                break;
        case '(':
        case ')':
```

```
        case '#':
                return 1;
                break;
    }
}
int isoperator(char symbol)
{
    switch(symbol)
    {
        case '+':
        case '-':
        case '*':
        case '/':
        case '^':
        case '$':
        case '(':
        case ')':
                return 1;
                  break;
        default:
                return 0;
    }
}

void convertip(char infix[],char postfix[])
{
        int i,symbol,j = 0;
        stack[++top] = '#';
        for(i=0;i<strlen(infix);i++)
        {
                symbol = infix[i];
                if(isoperator(symbol) == 0)
                {
                        postfix[j] = symbol;
                        j++;
                }
                else
                {
                        if(symbol == '(')
                                push(symbol);
                        else if(symbol == ')')
                        {
                                while(stack[top] != '(')
                                {
                                        postfix[j] = pop();
                                        j++;
                                }
                                pop(); //pop out (.
                        }
                        else
				{
					if(prcd(symbol) > prcd(stack[top]))
						push(symbol);
					else
					{
						while(prcd(symbol) <= prcd(stack[top]))
						{
						postfix[j] = pop();
						j++;
						}
						push(symbol);
					}
				}
			}
		}


		while(stack[top] != '#')
		{
			postfix[j] = pop();
			j++;
		}
		postfix[j] = '\0';
}
main()
{
   char infix[20],postfix[20];
   clrscr();
   printf("Enter the valid infix string: ");
   gets(infix);
   convertip(infix, postfix);
   printf("The corresponding postfix string is: ");
   puts(postfix);
   getch();
}
void push(char item)
{
		top++;
		stack[top] = item;
}

char pop()
{
		char a;
		a = stack[top];
		top--;
		return a;
}
```

Output

```
Enter the valid infix string: (a+b*c)/(d$e)
The corresponding postfix string is: abc*+de$/
Enter the valid infix string: a*b+c*d/e
The corresponding postfix string is: ab*cd*e/+
Enter the valid infix string: a+b*c+(d*e+f)*g
The corresponding postfix string is: abc*+de*f+g*+
```

Result: Thus the given infix expression was converted into postfix form using stack.

Ex. No. 4c EXPRESSION EVALUATION

Date:

Aim: To evaluate the given postfix expression using stack operations.

Algorithm

```
1. Start
2. Define a array stack of size max = 20
3. Initialize top = -1
4. Read the postfix expression character-by-character
5. If character is an operand push it onto the stack
6. If character is an operator
7. Pop topmost two elements from stack.
8. Apply operator on the elements and push the result onto the stack,
   Eventually only result will be in the stack at end of the expression.
9. Pop the result and print it.
```

Program

```
/* Evaluation of Postfix expression using stack */
#include <stdio.h>
#include <conio.h>
struct stack
{
        int top;
        float a[50];
}s;
main()
{
        char pf[50];
        float d1,d2,d3;
        int i;
        clrscr();
        s.top = -1;
        printf("\n\n Enter the postfix expression: ");
        gets(pf);
        for(i=0; pf[i]!='\0'; i++)
        {
          switch(pf[i])
          {
                case '0':
                case '1':
                case '2':
                case '3':
                case '4':
                case '5':
                case '6':
                case '7':
                case '8':
                case '9':
                        s.a[++s.top] = pf[i]-'0';
                        break;
                case '+':
                        d1 = s.a[s.top--];
                        d2 = s.a[s.top--];
                        s.a[++s.top] = d1 + d2;
                        break;
                case '-':
                        d2 = s.a[s.top--];
                        d1 = s.a[s.top--];
                        s.a[++s.top] = d1 - d2;
                        break;
                case '*':
                        d2 = s.a[s.top--];
                        d1 = s.a[s.top--];
                        s.a[++s.top] = d1*d2;
                        break;
                case '/':
                        d2 = s.a[s.top--];
                        d1 = s.a[s.top--];
                        s.a[++s.top] = d1 / d2;
                        break;
                }
            }

        printf("\n Expression value is %5.2f", s.a[s.top]);
        getch();
}
```

Output

```
Enter the postfix expression: 6523+8*+3+*
Expression value is 288.00
```

Result: Thus the given postfix expression was evaluated using stack.

Ex No. 5 **IMPLEMENTATION BINARY SEARCH TREE**
Date:

Aim: To construct a binary search tree and perform search.

Algorithm

1. Start
2. Call insert to insert an element into binary search tree.
3. Call delete to delete an element from binary search tree.
4. Call findmax to find the element with maximum value in binary search tree
5. Call findmin to find the element with minimum value in binary search tree
6. Call find to check the presence of the element in the binary search tree
7. Call display to display the elements of the binary search tree
8. Call makeempty to delete the entire tree.
9. Stop

Insert function

1. Get the element to be inserted.
2. Find the position in the tree where the element to be inserted by checking the elements in the tree by traversing from the root.
3. If the element to be inserted is less than the element in the current node in the tree then traverse left subtree
4. If the element to be inserted is greater than the element in the current node in the tree then traverse right subtree
5. Insert the element if there is no further move

Delete function

1. Get the element to be deleted.
2. Find the node in the tree that contain the element.
3. Delete the node an rearrange the left and right siblings if any present for the deleted node

Findmax function

1. Traverse the tree from the root.
2. Find the rightmost leaf node of the entire tree and return it
3. If the tree is empty return null.

Findmin function

1. Traverse the tree from the root.
2. Find the leftmost leaf node of the entire tree and return it
3. If the tree is empty return null.

Find function

1. Traverse the tree from the root.
2. Check whether the element to searched matches with element of the current node. If match occurs return it.
3. Otherwise if the element is less than that of the element of the current node then search the leaf subtree
4. Else search right subtree.

Makeempty function

Make the root of the tree to point to null.

Program

```
#include<stdio.h>
#include<stdlib.h>
#include<conio.h>
struct searchtree
{
    int element;
    struct searchtree *left,*right;
}*root;
typedef struct searchtree *node;
typedef int ElementType;
node insert(ElementType, node);
node delete(ElementType, node);
void makeempty();
node findmin(node);
node findmax(node);
node find(ElementType, node);
void display(node, int);
void main()
{
    int ch;
    ElementType a;
    node temp;
    makeempty();
    while(1)
    {
        printf("\n1. Insert\n2. Delete\n3. Find\n4. Find min\n5. Find max\n6.Display\n7.
        Exit\nEnter Your Choice : ");
        scanf("%d",&ch);
        switch(ch)
        {
            case 1:
                printf("Enter an element : ");
                scanf("%d", &a);
                root = insert(a, root);
                break;
            case 2:
                printf("\nEnter the element to delete : ");
                scanf("%d",&a);
                root = delete(a, root);
                break;
            case 3:
                 printf("\nEnter the element to search : ");
                 scanf("%d",&a);
                 temp = find(a, root);
                 if (temp != NULL)
                 printf("Element found");
```

```
                    else
                    printf("Element not found");
                    break;
                case 4:
                    temp = findmin(root);
                    if(temp==NULL)
                    printf("\nEmpty tree");
                    else
                    printf("\nMinimum element : %d", temp->element);
                    break;
                case 5:
                    temp = findmax(root);
                    if(temp==NULL)
                    printf("\nEmpty tree");
                    else
                    printf("\nMaximum element : %d", temp->element);
                    break;
                case 6:
                    if(root==NULL)printf("\nEmpty tree");
                    else
                    display(root, 1);
                    break;
                case 7:
                exit(0);
                default:
                printf("Invalid Choice");
            }
        }
}

node insert(ElementType x,node t)
{
    if(t==NULL)
    {
        t = (node)malloc(sizeof(node));
        t->element = x;
        t->left = t->right = NULL;
    }
    else
    {
        if(x < t->element)
        t->left = insert(x, t->left);
        else
        if(x > t->element)t->right = insert(x, t->right);
    }
    return t;
}

node delete(ElementType x,node t)
{
        node  temp;
        if(t == NULL)
        printf("\nElement not found");
        else
        {
               if(x < t->element)
               t->left = delete(x, t->left);
               else if(x > t->element)
               t->right = delete(x, t->right);
               else
               {
               if(t->left && t->right)
               {
               temp = findmin(t->right);
               t->element = temp->element;
               t->right = delete(t->element,t->right);
               }
               else if(t->left == NULL)
               {
               temp = t;
               t=t->right;
               free (temp);
               }
               else
               {
                              temp = t;
                              t=t->left;
                              free (temp);
               }
        }
        }
        return t;
}

void makeempty()
{
      root = NULL;
}

node findmin(node temp)
{
      if(temp == NULL || temp->left == NULL)
                  return temp;
      return findmin(temp->left);
}

node findmax(node temp)
{
      if(temp==NULL || temp->right==NULL)
                  return temp;
```

```
     return findmax(temp->right);
}

node find(ElementType x, node t)
{
     if(t==NULL)
                return NULL;
     if(x<t->element)
               return find(x,t->left);
     if(x>t->element)
      return find(x,t->right);
return t;
}

void display(node t,int level)
{
     int i;
     if(t)
     {
     display(t->right, level+1);
     printf(" \n");
     for(i=0;i<level;i++)
     printf(" ");
     printf("%d", t->element);
     display(t->left, level+1);
     }
}
```

Sample Output:

```
 1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit

Enter your Choice : 1
Enter an element : 10

1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit

Enter your Choice : 1
Enter an element : 20
1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit

Enter your Choice : 1
Enter an element : 5
1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit
Enter your Choice : 4
The smallest Number is 5

1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit
Enter your Choice : 3
Enter an element : 100
Element not Found

1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit

Enter your Choice : 2
Enter an element : 20

1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit
```

```
Enter your Choice : 6
          20
10

1. Insert
2. Delete
3. Find
4. Find Min
5. Find Max
6. Display
7. Exit
Enter your Choice : 7
```

Result:
The program for binary search tree is executed and verified.

Ex. No.6 **IMPLEMENTATION OF AVL TREES**
Date:

Aim: To implement AVL Trees.

Algorithm

A binary search tree x is called an AVL tree,
if:
1. b(x.key) ∈ {−1, 0, 1}, and
2. x.leftChild and x.rightChild are both AVL trees. = the height balance of every node must be -1, 0, or 1

insert/delete via standard algorithms
• after insert/delete: load balance b(node) might be changed to +2 or −2 for certain nodes
• re-balance load after each step

Insert operation may cause balance factor to become 2 or –2 for some node
› only nodes on the path from insertion point to root node have possibly changed in height
› So after the Insert, go back up to the root node by node, updating heights
› If a new balance factor (the difference hleft – hright) is 2 or –2, adjust tree by rotation around the node
Let the node that needs rebalancing be α.
There are 4 cases:
Outside Cases (require single rotation) :
1. Insertion into left subtree of left child of α.
2. Insertion into right subtree of right child of α.
Inside Cases (require double rotation) :
3. Insertion into right subtree of left child of α.
4. Insertion into left subtree of right child of α.
The rebalancing is performed through four separate rotation algorithms.
You can either keep the height or just the difference in height, i.e. the balance factor; this has to be modified on the path of insertion even if you donꞌꞌt perform rotations
Once you have performed a rotation (single or double) you wonꞌꞌt need to go back up the tree

SINGLE ROTATION

```
RotateFromRight(n : reference node pointer)
{
p : node pointer;
p := n.right;
n.right := p.left;
p.left := n;
n := p
}
```

You also need to modify the heights or balance factors of n and p

DOUBLE ROTATION

```
DoubleRotateFromRight(n : reference node pointer)
 {
RotateFromLeft(n.right);
RotateFromRight(n);
}
```

INSERTION IN AVL TREES

```
Insert(T : tree pointer, x : element) :
{
if T = null then
T := new tree; T.data := x; height := 0;
case
T.data = x : return ; //Duplicate do nothing
T.data > x : return Insert(T.left, x);
if ((height(T.left)- height(T.right)) = 2){
if (T.left.data > x ) then //outside case
T = RotatefromLeft (T);
else //inside case
T = DoubleRotatefromLeft (T);}
T.data < x : return Insert(T.right, x);
code similar to the left case
Endcase
T.height := max(height(T.left),height(T.right)) +1;
return;
}
```

DELETION

Similar but more complex than insertion

› Rotations and double rotations needed to rebalance

› Imbalance may propagate upward so that many rotations may be needed.

Program

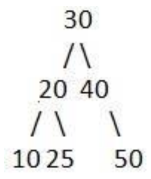
```
// C program to insert a node in AVL tree
#include<stdio.h>
#include<stdlib.h>

// An AVL tree node
struct Node
{
    int key;
    struct Node *left;
    struct Node *right;
    int height;
};

// A utility function to get maximum of two integers
int max(int a, int b);
```

```
// A utility function to get the height of the tree
int height(struct Node *N)
{
    if (N == NULL)
            return 0;
    return N->height;
}

// A utility function to get maximum of two integers
int max(int a, int b)
{
    return (a > b)? a : b;
}

/* Helper function that allocates a new node with the given key and
    NULL left and right pointers. */
struct Node* newNode(int key)
{
    struct Node* node = (struct Node*)
                                        malloc(sizeof(struct Node));
    node->key = key;
    node->left = NULL;
    node->right = NULL;

    node->height = 1; // new node is initially added at leaf
    return(node);
}

// A utility function to right rotate subtree rooted with y
// See the diagram given above.
struct Node *rightRotate(struct Node *y)
{
    struct Node *x = y->left;
    struct Node *T2 = x->right;

    // Perform rotation
    x->right = y;
    y->left = T2;

    // Update heights
    y->height = max(height(y->left), height(y->right))+1;
    x->height = max(height(x->left), height(x->right))+1;

    // Return new root
    return x;
}

// A utility function to left rotate subtree rooted with x
// See the diagram given above.
struct Node *leftRotate(struct Node *x)
```

```
{
    struct Node *y = x->right;
    struct Node *T2 = y->left;

    // Perform rotation
    y->left = x;
    x->right = T2;

    // Update heights
    x->height = max(height(x->left), height(x->right))+1;
    y->height = max(height(y->left), height(y->right))+1;

    // Return new root
    return y;
}

// Get Balance factor of node N
int getBalance(struct Node *N)
{
    if (N == NULL)
            return 0;
    return height(N->left) - height(N->right);
}

// Recursive function to insert a key in the subtree rooted
// with node and returns the new root of the subtree.
struct Node* insert(struct Node* node, int key)
{
    /* 1. Perform the normal BST insertion */
    if (node == NULL)
            return(newNode(key));

    if (key < node->key)
            node->left = insert(node->left, key);
    else if (key > node->key)
            node->right = insert(node->right, key);
    else // Equal keys are not allowed in BST
            return node;

    /* 2. Update height of this ancestor node */
    node->height = 1 + max(height(node->left),
                                        height(node->right));

    /* 3. Get the balance factor of this ancestor
            node to check whether this node became
            unbalanced */
    int balance = getBalance(node);

    // If this node becomes unbalanced, then
    // there are 4 cases
    // Left Left Case
    if (balance > 1 && key < node->left->key)
            return rightRotate(node);

    // Right Right Case
    if (balance < -1 && key > node->right->key)
            return leftRotate(node);

    // Left Right Case
    if (balance > 1 && key > node->left->key)
    {
            node->left = leftRotate(node->left);
            return rightRotate(node);
    }

    // Right Left Case
    if (balance < -1 && key < node->right->key)
    {
            node->right = rightRotate(node->right);
            return leftRotate(node);
    }

    /* return the (unchanged) node pointer */
    return node;
}

// A utility function to print preorder traversal
// of the tree.
// The function also prints height of every node
void preOrder(struct Node *root)
{
    if(root != NULL)
    {
            printf("%d ", root->key);
            preOrder(root->left);
            preOrder(root->right);
    }
}

/* Drier program to test above function*/
int main()
{
struct Node *root = NULL;

/* Constructing tree given in the above figure */
root = insert(root, 10);
root = insert(root, 20);
root = insert(root, 30);
root = insert(root, 40);
root = insert(root, 50);
root = insert(root, 25);

printf("Preorder traversal of the constructed AVL"
            " tree is \n");
preOrder(root);
return 0;
}
```

OUTPUT

The constructed AVL Tree would be



```
    30
    /\
  20  40
  / \   \
10 25    50
```

<u>Result:</u> Thus the implementation of AVL tree was demonstrated.

Ex. No.7 IMPLEMENTATION OF HEAP USING PRIORITY QUEUES
Date:

Aim To Implementation Of Heap Using Priority Queues.

Algorithm

- Priority queue is a type of queue in which every element has a key associated to it and the queue returns the element according to these keys, unlike the traditional queue which works on first come first serve basis.

- Thus, a max-priority queue returns the element with maximum key first whereas, a min-priority queue returns the element with the smallest key first.

  max-priority queue and min-priority queue

- Priority queues are used in many algorithms like Huffman Codes, Prim's algorithm, etc. It is also used in scheduling processes for a computer, etc.

- Heaps are great for implementing a priority queue because of the largest and smallest element at the root of the tree for a max-heap and a min-heap respectively. We use a max-heap for a max-priority queue and a min-heap for a min-priority queue.

There are mainly 4 operations we want from a priority queue:

1. **Insert** → To insert a new element in the queue.

2. **Maximum/Minimum** → To get the maximum and the minimum element from the max-priority queue and min-priority queue respectively.

3. **Extract Maximum/Minimum** → To remove and return the maximum and the minimum element from the max-priority queue and min-priority queue respectively.

4. **Increase/Decrease key** → To increase or decrease key of any element in the queue.

- A priority queue stores its data in a specific order according to the keys of the elements. So, inserting a new data must go in a place according to the specified order. This is what the insert operation does.
- The entire point of the priority queue is to get the data according to the key of the data and the Maximum/Minimum and Extract Maximum/Minimum does this for us.
- We know that the maximum (or minimum) element of a priority queue is at the root of the max-heap (or min-heap). So, we just need to return the element at the root of the heap.

- This is like the pop of a queue, we return the element as well as **delete** it from the heap. So, we have to return and delete the root of a heap. Firstly, we store the value of the root in a variable to return it later from the function and then we just make the root equal to the last element of the heap. Now the root is equal to the last element of the heap, we delete the last element easily by reducing the size of the heap by 1.

- Doing this, we have disturbed the heap property of the root but we have not touched any of its children, so they are still heaps. So, we can call *Heapify* on the root to make the tree a heap again.

```
EXTRACT-MAXIMUM(A)

  max = A[1] // stroing maximum value

  A[1] = A[heap_size] // making root equal to the last element

  heap_size = heap_size-1 // delete last element

  MAX-HEAPIFY(A, 1) // root is not following max-heap property

  return max //returning the maximum value
```

<u>Program</u>

```
#include <stdio.h>

int tree_array_size = 20;
int heap_size = 0;
const int INF = 100000;

void swap( int *a, int *b )
 {
  int t;
  t = *a;
  *a = *b;
  *b = t;
}

//function to get right child of a node of a tree
int get_right_child(int A[], int index)
 {
  if((((2*index)+1) < tree_array_size) && (index >= 1))
    return (2*index)+1;
  return -1;
}

//function to get left child of a node of a tree
int get_left_child(int A[], int index)
 {
    if(((2*index) < tree_array_size) && (index >= 1))
        return 2*index;
    return -1;
}

//function to get the parent of a node of a tree
int get_parent(int A[], int index)
{
  if ((index > 1) && (index < tree_array_size))
 {
    return index/2;
  }
  return -1;
}

void max_heapify(int A[], int index)
 {
  int left_child_index = get_left_child(A, index);
  int right_child_index = get_right_child(A, index);

  // finding largest among index, left child and right child
  int largest = index;

  if ((left_child_index <= heap_size) && (left_child_index>0))
 {
    if (A[left_child_index] > A[largest]) {
      largest = left_child_index;
    }
  }

  if ((right_child_index <= heap_size && (right_child_index>0)))
{
    if (A[right_child_index] > A[largest])
{
      largest = right_child_index;
    }
  }

  // largest is not the node, node is not a heap
  if (largest != index)
{
    swap(&A[index], &A[largest]);
    max_heapify(A, largest);
  }
}

void build_max_heap(int A[])
{
  int i;
  for(i=heap_size/2; i>=1; i--)
{
    max_heapify(A, i);
  }
}

int maximum(int A[])
{
  return A[1];
}

int extract_max(int A[])
{
  int maxm = A[1];
  A[1] = A[heap_size];
  heap_size--;
  max_heapify(A, 1);
  return maxm;
}

void increase_key(int A[], int index, int key)
 {
  A[index] = key;
  while((index>1) && (A[get_parent(A, index)] < A[index]))
  {
    swap(&A[index], &A[get_parent(A, index)]);
    index = get_parent(A, index);
  }
}

void decrease_key(int A[], int index, int key)
 {
  A[index] = key;
  max_heapify(A, index);
}

void insert(int A[], int key)
```

```
 {
  heap_size++;
  A[heap_size] = -1*INF;
  increase_key(A, heap_size, key);
}

void print_heap(int A[])
{
  int i;
  for(i=1; i<=heap_size; i++)
 {
    printf("%d\n",A[i]);
  }
  printf("\n");
}

int main()
 {
  int A[tree_array_size];
  insert(A, 20);
  insert(A, 15);
  insert(A, 8);
  insert(A, 10);
  insert(A, 5);
  insert(A, 7);
  insert(A, 6);
  insert(A, 2);
  insert(A, 9);
  insert(A, 1);

  print_heap(A);

  increase_key(A, 5, 22);
  print_heap(A);

  decrease_key(A, 1, 13);
  print_heap(A);

  printf("%d\n\n", maximum(A));
  printf("%d\n\n", extract_max(A));

  print_heap(A);

  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
  printf("%d\n", extract_max(A));
```

```
    printf("%d\n", extract_max(A));
    printf("%d\n", extract_max(A));
    return 0;
  }
```

OUTPUT

```
Priority Queue using Heap:
Enter the number of elements: 7
Enter elements: 234
6543
12234
64
536
876
77
PQueue: 64 77 234 536 876 6543 12234
```

RESULT:

Thus the implementation heap using priority queue was demonstrated.

Ex. No. 8a **REPRESENTATION OF GRAPH**
Date:

Aim To represent graph using adjacency list.

Algorithm

- For a graph with |V| vertices, an **adjacency matrix** is a |V|×|V| matrix of 0s and 1s, where the entry in row i and column j is 1 if and only if the edge (i,j) in the graph.

1. Consider the graph to be represented
2. Start from an edge
3. If the edge connects the vertices i,j the mark the ith row and jth column of the adjacency matrix as 1 otherwise store 0
4. Finally print the adjacency matrix

Program

```
#include<stdio.h>
#define V 5

//init matrix to 0
void init(int arr[][V])
{
   int i,j;
   for(i = 0; i < V; i++)
      for(j = 0; j < V; j++)
         arr[i][j] = 0;
}

//Add edge. set arr[src][dest] = 1
void addEdge(int arr[][V],int src, int dest)
{
    arr[src][dest] = 1;
}

void printAdjMatrix(int arr[][V])
{
    int i, j;

    for(i = 0; i < V; i++)
    {
       for(j = 0; j < V; j++)
       {
          printf("%d ", arr[i][j]);
       }
       printf("\n");
    }
}

//print the adjMatrix
int main()
{
   int adjMatrix[V][V];

   init(adjMatrix);
   addEdge(adjMatrix,0,1);
   addEdge(adjMatrix,0,2);
   addEdge(adjMatrix,0,3);
   addEdge(adjMatrix,1,3);
   addEdge(adjMatrix,1,4);
   addEdge(adjMatrix,2,3);
   addEdge(adjMatrix,3,4);

   printAdjMatrix(adjMatrix);

   return 0;
}
```

OUTPUT

```
0 1 1 1 0
0 0 0 1 1
0 0 0 1 0
0 0 0 0 1
0 0 0 0 0
```

Result : Thus the implementation of graph representation was demonstrated.

Ex. No. 8b **GRAPH TRAVERSAL-BREADTH FIRST TRAVERSAL**
Date:

Aim To implement breadth first graph traversal.

Algorithm

```
BFS (G, s)                  //Where G is the graph and s is the source node
    let Q be queue.
    Q.enqueue( s ) //Inserting s in queue until all its neighbour vertices are marked.

    mark s as visited.
    while ( Q is not empty)
        //Removing that vertex from queue,whose neighbour will be visited now
        v  = Q.dequeue( )

       //processing all the neighbours of v
       for all neighbours w of v in Graph G
           if w is not visited
                  Q.enqueue( w )          //Stores w in Q to further visit its neighbour
                  mark w as visited.
```

Program

```
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

#define MAX 5

struct Vertex {
   char label;
   bool visited;
};

//queue variables

int queue[MAX];
int rear = -1;
int front = 0;
int queueItemCount = 0;

//graph variables

//array of vertices
struct Vertex* lstVertices[MAX];

//adjacency matrix
int adjMatrix[MAX][MAX];
```

```
//vertex count
int vertexCount = 0;

//queue functions

void insert(int data) {
  queue[++rear] = data;
  queueItemCount++;
}

int removeData() {
  queueItemCount--;
  return queue[front++];
}

bool isQueueEmpty() {
  return queueItemCount == 0;
}

//graph functions

//add vertex to the vertex list
void addVertex(char label) {
  struct Vertex* vertex = (struct Vertex*) malloc(sizeof(struct Vertex));
  vertex->label = label;
  vertex->visited = false;
  lstVertices[vertexCount++] = vertex;
}

//add edge to edge array
void addEdge(int start,int end) {
  adjMatrix[start][end] = 1;
  adjMatrix[end][start] = 1;
}

//display the vertex
void displayVertex(int vertexIndex) {
  printf("%c ",lstVertices[vertexIndex]->label);
}

//get the adjacent unvisited vertex
int getAdjUnvisitedVertex(int vertexIndex) {
  int i;

  for(i = 0; i<vertexCount; i++) {
    if(adjMatrix[vertexIndex][i] == 1 && lstVertices[i]->visited == false)
      return i;
  }
  return -1;
}

void breadthFirstSearch() {
  int i;

  //mark first node as visited
  lstVertices[0]->visited = true;

  //display the vertex
  displayVertex(0);

  //insert vertex index in queue
  insert(0);
  int unvisitedVertex;

  while(!isQueueEmpty()) {
    //get the unvisited vertex of vertex which is at front of the queue
    int tempVertex = removeData();

    //no adjacent vertex found
    while((unvisitedVertex = getAdjUnvisitedVertex(tempVertex)) != -1) {
      lstVertices[unvisitedVertex]->visited = true;
      displayVertex(unvisitedVertex);
      insert(unvisitedVertex);
    }

  }

  //queue is empty, search is complete, reset the visited flag
  for(i = 0;i<vertexCount;i++) {
    lstVertices[i]->visited = false;
  }
}

int main() {
  int i, j;

  for(i = 0; i<MAX; i++) // set adjacency {
    for(j = 0; j<MAX; j++) // matrix to 0
      adjMatrix[i][j] = 0;
  }

  addVertex('S');   // 0
  addVertex('A');   // 1
  addVertex('B');   // 2
  addVertex('C');   // 3
  addVertex('D');   // 4

  addEdge(0, 1);    // S - A
```

```
   addEdge(0,  2);  //  S  -  B
   addEdge(0,  3);  //  S  -  C
   addEdge(1,  4);  //  A  -  D
   addEdge(2,  4);  //  B  -  D
   addEdge(3, 4);  // C - D

   printf("\nBreadth First Search: ");

   breadthFirstSearch();

   return 0;
}
```

Output

```
Breadth First Search: S A B C D
```

Result : Thus the graph using breadth first search traversal was demonstrated.

Ex. No. 8c **GRAPH TRAVERSAL-DEPTH FIRST TRAVERSAL**
Date:

Aim To implement Depth first graph traversal.

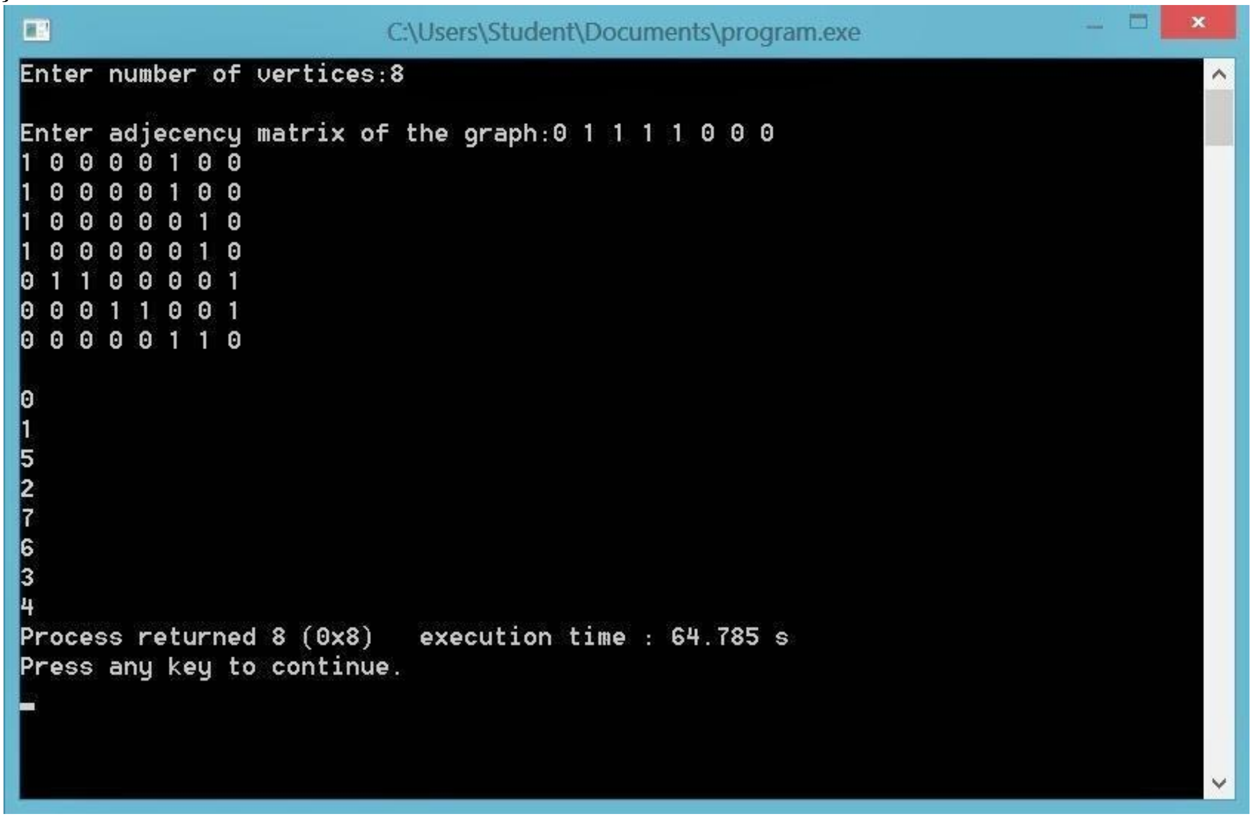
Algorithm

```
DFS-iterative (G, s):                          //Where G is graph and s is source vertex
    let S be stack
    S.push( s )          //Inserting s in stack
    mark s as visited.
    while ( S is not empty):
        //Pop a vertex from stack to visit next
        v  =  S.top( )
       S.pop( )
       //Push all the neighbours of v in stack that are not visited
      for all neighbours w of v in Graph G:
          if w is not visited :
                 S.push(  w )
                mark w as visited


  DFS-recursive(G, s):
      mark s as visited
      for all neighbours w of s in Graph G:
          if w is not visited:
              DFS-recursive(G, w)
```

Program

```
#include<stdio.h>

void DFS(int);
int G[10][10],visited[10],n;    //n is no of vertices and graph is sorted in array G[10][10]

void main()
{
   int i,j;
   printf("Enter number of vertices:");

     scanf("%d",&n);

   //read the adjecency matrix
     printf("\nEnter adjecency matrix of the graph:");

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

```
    //visited is initialized to zero
   for(i=0;i<n;i++)
        visited[i]=0;

    DFS(0);
}

void DFS(int i)
{
    int j;
    printf("\n%d",i);
    visited[i]=1;

      for(j=0;j<n;j++)
       if(!visited[j]&&G[i][j]==1)
            DFS(j);
}
```



```
Enter number of vertices:8

Enter adjecency matrix of the graph:0 1 1 1 1 0 0 0
1 0 0 0 0 1 0 0
1 0 0 0 0 1 0 0
1 0 0 0 0 0 1 0
1 0 0 0 0 0 1 0
0 1 1 0 0 0 0 1
0 0 0 1 1 0 0 1
0 0 0 0 0 1 1 0

0
1
5
2
7
6
3
4
Process returned 8 (0x8)   execution time : 64.785 s
Press any key to continue.
```

<u>Result :</u> Thus the graph using depth first search traversal was demonstrated.

Ex. No. 9a **LINEAR SEARCH**
Date:

AimTo perform linear search of an element on the given array.

Algorithm

```
1. Start
2. Read number of array elements n
3. Read array elements Ai, i = 0,1,2,…n–1
4. Read search value
5. Assign 0 to found
6. Check each array element against search
7. If Ai = search then
   found = 1
   Print "Element found"
   Print position i
   Stop
8. If found = 0 then
   print "Element not found"
Stop
```

Program

```
/* Linear search on a sorted array */
#include <stdio.h>
#include <conio.h>
main()
{
    int a[50],i, n, val, found;
    clrscr();
    printf("Enter number of elements : ");
    scanf("%d", &n);
    printf("Enter Array Elements : \n");
    for(i=0; i<n; i++)
    scanf("%d", &a[i]);
    printf("Enter element to locate : ");
    scanf("%d", &val);
    found = 0;
    for(i=0; i<n; i++)
    {
        if (a[i] == val)
        {
            printf("Element found at position %d", i);
            found = 1;
            break;
        }
    }
    if (found == 0)
    printf("\n Element not found");
    getch();
}
```

Output

```
Enter number of elements : 7
Enter Array Elements :
23 6 12 5 0 32 10
Enter element to locate : 5
Element found at position 3
```

Result

Thus an array was linearly searched for an element's existence.

Ex. No. 9b **BINARY SEARCH**
Date:

Aim
To locate an element in a sorted array using Binary search method

Algorithm

```
1. Start
2. Read number of array elements, say n
3. Create an array arr consisting n sorted elements
4. Get element, say key to be located
5. Assign 0 to lower and n to upper
6. While (lower < upper)
      a. Determine middle element mid = (upper+lower)/2
      b. If key = arr[mid] then
            i. Print mid
           ii. Stop
      c. Else if key > arr[mid] then
            i. lower = mid + 1
      d. else
            i. upper = mid – 1
7. Print "Element not found"
8. Stop
```

Program

```
/* Binary Search on a sorted array */
#include <stdio.h>
void main()
{
    int a[50],i, n, upper, lower, mid, val, found, att=0;
    printf("Enter array size : ");
    scanf("%d", &n);
    for(i=0; i<n; i++)
    a[i] = 2 * i;
    printf("\n Elements in Sorted Order \n");
    for(i=0; i<n; i++)
    printf("%4d", a[i]);
    printf("\n Enter element to locate : ");
    scanf("%d", &val);
    upper = n;
    lower = 0;
    found = -1;
    while (lower <= upper)
    {
       mid = (upper + lower)/2;
       att++;
       if (a[mid] == val)
       {
            printf("Found at index %d in %d attempts", mid, att);
            found = 1;
            break;
        }
        else if(a[mid] > val)
        upper = mid - 1;
        else
        lower = mid + 1;
    }
    if (found == -1)
    printf("Element not found");
}
```

Output

```
Enter array size : 10
Elements in Sorted Order
0 2 4 6 8 10 12 14 16 18
Enter element to locate : 16
Found at index 8 in 2 attempts
```

Result

Thus an element is located quickly using binary search method.

Ex. No. 10a **INSERTION SORT**
Date:

Aim: To sort an array of N numbers using Insertion sort.

Algorithm

1. Start
2. Read number of array elements n
3. Read array elements Ai
4. Outer index i varies from second element to last element
5. Inner index j is used to compare elements to left of outer index
6. Insert the element into the appropriate position.
7. Display the array elements after each pass
8. Display the sorted array elements.
9. Stop

Program

```
/* 11a - Insertion Sort */
void main()
{
    int i, j, k, n, temp, a[20], p=0;
    printf("Enter total elements: ");
    scanf("%d",&n);
    printf("Enter array elements: ");
    for(i=0; i<n; i++)
    scanf("%d", &a[i]);
    for(i=1; i<n; i++)
    {
        temp = a[i];
        j = i - 1;
        while((temp<a[j]) && (j>=0))
        {
            a[j+1] = a[j];
            j = j - 1;
        }
        a[j+1] = temp;
        p++;
        printf("\n After Pass %d: ", p);
        for(k=0; k<n; k++)
        printf(" %d", a[k]);
    }
    printf("\n Sorted List : ");
    for(i=0; i<n; i++)
    printf(" %d", a[i]);
}
```

Output

```
Enter total elements: 6
Enter array elements: 34 8 64 51 32 21
After Pass 1: 8 34 64 51 32 21
After Pass 2: 8 34 64 51 32 21
After Pass 3: 8 34 51 64 32 21
After Pass 4: 8 32 34 51 64 21
After Pass 5: 8 21 32 34 51 64
Sorted List : 8 21 32 34 51 64
```

Result: Thus array elements was sorted using insertion sort.

Ex. No. 10b **BUBBLE SORT**
Date:

Aim: To sort an array of N numbers using Bubble sort.

Algorithm

```
1. Start
2. Read number of array elements n
3. Read array elements Ai
4. Outer Index i varies from last element to first element
      a. Index j varies from first element to i-1
            i. Compare elements Aj and Aj+1
           ii. If out-of-order then swap the elements
          iii. Display array elements after each pass
           iv. Display the final sorted list
5. Stop
```

Program

```
/* 11b - Bubble Sort */
#include <stdio.h>
main()
{
    int n, t, i, j, k, a[20], p=0;
    printf("Enter total numbers of elements: ");
    scanf("%d", &n);
    printf("Enter %d elements: ", n);
    for(i=0; i<n; i++)
    scanf("%d", &a[i]);
    for(i=n-1; i>=0; i--)
    {
        for(j=0; j<i; j++)
        {
            if(a[j] > a[j+1])
            {
                t = a[j];
                a[j] = a[j+1];
                a[j+1] = t;
            }
        }
    p++;
    printf("\n After Pass %d : ", p);
    for(k=0; k<n; k++)
    printf("%d ", a[k]);
    }
    printf("\n Sorted List : ");
    for(i=0; i<n; i++)
    printf("%d ", a[i]);
}
```

Output
```
Enter total numbers of elements: 8
Enter 8 elements: 8 6 10 3 1 2 5 4
After Pass 1 : 6 8 3 1 2 5 4 10
After Pass 2 : 6 3 1 2 5 4 8 10
After Pass 3 : 3 1 2 5 4 6 8 10
After Pass 4 : 1 2 3 4 5 6 8 10
After Pass 5 : 1 2 3 4 5 6 8 10
After Pass 6 : 1 2 3 4 5 6 8 10
After Pass 7 : 1 2 3 4 5 6 8 10
Sorted List : 1 2 3 4 5 6 8 10
```

Result
Thus an array was sorted using bubble sort.

<u>Ex. No. 10c</u> **<u>QUICK SORT</u>**
<u>Date:</u>

<u>Aim:</u>To sort an array of N numbers using Quick sort.

<u>Algorithm</u>

```
1. Start
2. Read number of array elements n
3. Read array elements Ai
4. Select an pivot element x from Ai
5. Divide the array into 3 sequences: elements < x, x, elements > x
6. Recursively quick sort both sets (Ai < x and Ai > x)
7. Display the sorted array elements
8. Stop
```

Program

```
/* 11c - Quick Sort */
#include<stdio.h>
#include<conio.h>
void qsort(int arr[20], int fst, int last);
main()
{
    int arr[30];
    int i, size;
    printf("Enter total no. of the elements : ");
    scanf("%d", &size);
    printf("Enter total %d elements : \n", size);
    for(i=0; i<size; i++)
    scanf("%d", &arr[i]);
    qsort(arr,0,size-1);
    printf("\n Quick sorted elements \n");
    for(i=0; i<size; i++)
    printf("%d\t", arr[i]);
    getch();
}


void qsort(int arr[20], int fst, int last)
{
    int i, j, pivot, tmp;
    if(fst < last)
    {
       pivot = fst;
       i = fst;
       j = last;
       while(i < j)
       {
            while(arr[i] <=arr[pivot] && i<last)
```

```
                i++;
                while(arr[j] > arr[pivot])
                j--;
                if(i <j )
                {
                      tmp = arr[i];
                      arr[i] = arr[j];
                      arr[j] = tmp;
                }
          }
          tmp = arr[pivot];
          arr[pivot] = arr[j];
          arr[j] = tmp;
          qsort(arr, fst, j-1);
          qsort(arr, j+1, last);
     }
}
```

Output

```
Enter total no. of the elements : 8
Enter total 8 elements :
127
-1
04
-2
3
Quick sorted elements
-2 -1 0 1 2 3 4 7
```

Result

Thus the array was sorted using quick sort‟s divide and conquers method.

Ex. No. 10d **MERGE SORT**
Date:

Aim: To sort an array of N numbers using Merge sort.

Algorithm

1. Start
2. Read number of array elements n
3. Read array elements Ai
4. Divide the array into sub-arrays with a set of elements
5. Recursively sort the sub-arrays
6. Display both sorted sub-arrays
7. Merge the sorted sub-arrays onto a single sorted array.
8. Display the merge sorted array elements
9. Stop

Program

```
/* 11d – Merge sort */
#include <stdio.h>
#include <conio.h>
void merge(int [],int ,int ,int );
void part(int [],int ,int );
int size;
main()
{
    int i, arr[30];
    printf("Enter total no. of elements : ");
    scanf("%d", &size);
    printf("Enter array elements : ");
    for(i=0; i<size;  i++)
    scanf("%d", &arr[i]);
    part(arr, 0, size-1);
    printf("\n Merge sorted list : ");
    for(i=0; i<size;  i++)
    printf("%d ",arr[i]);
    getch();
}

void part(int arr[], int min, int max)
{
    int mid;
    if(min < max)
    {
       mid = (min + max) / 2;
       part(arr, min, mid);
       part(arr, mid+1, max);
       merge(arr, min, mid, max);
    }
    if (max-min == (size/2)-1)
    {
        printf("\n Half sorted list : ");
        for(i=min; i<=max; i++)
        printf("%d ", arr[i]);
    }
}

void merge(int arr[],int min,int mid,int max)
{
    int  tmp[30];
    int i, j, k, m;
    j = min;
    m = mid + 1;
    for(i=min; j<=mid && m<=max; i++)
    {
        if(arr[j] <= arr[m])
        {
            tmp[i] = arr[j];
            j++;
        }
        else
        {
            tmp[i] = arr[m];
            m++;
        }
    }
    if(j > mid)
    {
        for(k=m; k<=max; k++)
        {
            tmp[i] = arr[k];
            i++;
        }
    }
    else
    {
        for(k=j; k<=mid; k++)
        {
            tmp[i] = arr[k];
            i++;
        }
    }
    for(k=min; k<=max; k++)
    arr[k] = tmp[k];
}
```

Output

```
Enter total no. of elements : 8
Enter array elements : 24 13 26 1 2 27 38 15
Half sorted list : 1 13 24 26
Half sorted list : 2 15 27 38
Merge sorted list : 1 2 13 15 24 26 27 38
```

Result

Thus array elements was sorted using merge sort's divide and conquer method.

ADDITIONAL EXPERIMENT- IMPLEMENTATION OF HASH FUNCTIONS AND COLLISION RESOLUTION TECHNIQUE

Date:

Aim: To implement hashing technique and collision resolution technique.

Algorithm

1. Start
2. A structure that represent the key, data pair is created
3. Key is generated by hashcode function which returns the value of key%size where size is assumed as 20
4. Insert function is called to insert a new key value pair into the hash table.
5. While inserting an element if the hashcode function returns a key that has been previously assigned to an element in the hash table then a collision occurs.
6. If there is a collision then the hash key is incremented to move to the next place and find whether there is a key-space for inserting the current element. This is called collision resolution. This process is repeated until a space if found for current element or the hash table is full
7. Delete function is called to delete an element from the hash table.
8. Stop

Program

```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <stdbool.h>

#define SIZE 20

struct DataItem
{
int data;
  int key;
};

struct DataItem* hashArray[SIZE];
struct DataItem* dummyItem;
struct DataItem* item;

int hashCode(int key)
{
return key % SIZE;
}

struct DataItem *search(int key)
{
     int hashIndex = hashCode(key);  //get the hash

     while(hashArray[hashIndex] != NULL) //move in array until an empty
{
       if(hashArray[hashIndex]->key == key)
 return hashArray[hashIndex];
    ++hashIndex;     //go to next cell
     hashIndex %= SIZE;      //wrap around the table
  }
  return NULL;
}

void insert(int key,int data)
{
  struct DataItem *item = (struct DataItem*) malloc(sizeof(struct DataItem));
  item->data = data;
  item->key = key;

   int hashIndex = hashCode(key);//get the hash

  //move in array until an empty or deleted cell
  while(hashArray[hashIndex] != NULL && hashArray[hashIndex]->key != -1)
{
        ++hashIndex;  //go to next cell
     hashIndex %= SIZE;      //wrap around the table
}
  hashArray[hashIndex] = item;
}

struct DataItem* delete(struct DataItem* item)
{
  int key = item->key;
  int hashIndex = hashCode(key);   //get the hash
  while(hashArray[hashIndex] != NULL)   //move in array until an empty
{
    if(hashArray[hashIndex]->key == key)
{
        struct DataItem* temp = hashArray[hashIndex];
        hashArray[hashIndex] = dummyItem; //assign a dummy item at deleted
                                                                     //position
        return temp;
     }
    ++hashIndex;      //go to next cell
     hashIndex %= SIZE;  //wrap around the table
  }
  return NULL;
}

void display()
{
  int i = 0;

  for(i = 0; i<SIZE; i++)
{
    if(hashArray[i] != NULL)
        printf(" (%d,%d)",hashArray[i]->key,hashArray[i]->data);
     else
        printf(" ~~ ");
  }
  printf("\n");
}

int main()
{
  dummyItem = (struct DataItem*) malloc(sizeof(struct DataItem));
  dummyItem->data = -1;
  dummyItem->key = -1;

  insert(1, 20);
  insert(2, 70);
  insert(42, 80);
  insert(4, 25);
  insert(12, 44);
  insert(14, 32);
  insert(17, 11);
  insert(13, 78);
  insert(37, 97);

  display();
  item = search(37);

  if(item != NULL)
{
     printf("Element found: %d\n", item->data);
} else
{
     printf("Element not found\n");
}

  delete(item);
  item = search(37);

  if(item != NULL)
{
     printf("Element found: %d\n", item->data);
  } else
{
     printf("Element not found\n");
  }
}
```

Output

```
 ~~  (1,20)  (2,70)  (42,80)  (4,25)  ~~  ~~  ~~  ~~ ~~  ~~  ~~ (12,44)  (13,78)
(14,32)  ~~  ~~  (17,11)  (37,97)  ~~
Element found: 97
Element not found
```

Result

The program for demonstrating hashing and collision resolution is executed and verified.

VIVA QUESTIONS

1. Define global declaration?
2. Define data types?
3. Define variable with example?
4. What is decision making statement?
5. What are the various decision making statements available in C ?
6. Distinguish between Call by value Call by reference.
7. What is an array?
8. What is two dimensional array?
9. Define is function?
10. What are the various looping statements available in „C‟?
11. What are the uses of Pointers?
12. What is a Pointer? How a variable is declared to the pointer? (MAY 2009)
13. What is the difference between if and while statement?
14. Define pre-processor in C.
15. Define recursive function?
16. What is the difference between while and do….while statement?
17. Define Operator with example?
18. Define conditional operator or ternary operator?
19. Compare of switch() case and nested if statement
20. What are steps involved in looping statements?
21. Define break statement?
22. Define null pointer?
23. Compare arrays and structures.
24. Compare structures and unions.
25. Define Structure in C.
26. Rules for declaring a structure?
27. Define structure pointers
28. Define union?
29. Define file?
30. Define binary files?
31. Define opening a file?
32. Define fseek()?
33. Functions of bit fields?
34. What is meant by an abstract data type?
35. Advantages and Disadvantages of arrays?
36. What is an array?
37. What is a linked list?
38. What is singly linked list?
39. What is a doubly linked list?
40. Define double circularly linked list?
41. What is the need for the header?
42. Define Polynomial ADT
43. How to search an element in list.
44. Define Dqueue?
45. How to implement stack using singly linked list
46. What are the types of Linear linked list?
47. What are advantages of Linked lists?
48. Write down the algorithm for solving Towers of Hanoi problem?

49. What is a Stack ?
50. What are the two operations of Stack?
51. What is a Queue ?
52. What is a Priority Queue?
53. What are the different ways to implement list?
55. What are the postfix and prefix forms of the expression?
56. Explain the usage of stack in recursive algorithm implementation?
57. Write down the operations that can be done with queue data structure?
58. What is a circular queue?
59. Give few examples for data structures?
60. List out Applications of queue
61. How do you test for an empty queue?
62. What are applications of stack?
63. Define recursion?
64. What are types of Queues?
65. What is meant by Sorting and searching?
66. What are the types of sorting available in C?
67. Define Bubble sort.
68. Mention the various types of searching techniques in C
69. What is linear search?
70. What is binary search?
71. Define merge sort?
72. Define insertion sort?
73. Define selection sort?
74. What is the basic idea of shell sort?
75. What is the purpose of quick sort and advantage?
76. Define quick sort?
77. Advantage of quick sort?
78. Define radix sort?
79. List out the different types of hashing functions?
80. Define hashing?
81. Define hash table?
82. What are the types of hashing?
83. Define Rehashing?
84. What is data structure?
85. What are the goals of Data Structure?
86. What does abstract Data Type Mean?
87. What is the difference between a Stack and an Array?
88. What do you mean by recursive definition?
89. What is sequential search?
90. What actions are performed when a function is called?
91. What actions are performed when a function returns?