Ex : 1

Title: Write a program in C to create a data structure which can handle varying number of entries and sort it.

Problem Description: Need to create a data structure which makes use of memory dynamically. The sorting can be done using any technique.

Method: The method utilized here is the use of dynamic memory allocation functions and define a function to perform selection sort.

Theory Reference: Module 1

Explanation:

1. Dynamic Memory Allocation:
o The array a is dynamically allocated using malloc(). The size of the array is determined at runtime based on user input.
2. Selection Sort:
o The selectionSort function sorts the array by repeatedly finding the minimum element from the unsorted part and swapping it with the first element of the unsorted part.
3. Freeing Memory:
o After sorting, the dynamically allocated memory is freed using free() to avoid memory leaks.

Algorithm

Step 1: start

Step 2: First, we will select the range of the unsorted array using a loop (say i) that indicates the starting index of the range. The loop will run forward from 0 to n-1. Set pos to location i (i=0 initially).

Step 3: Search the minimum element in the list. Step 4: Swap with value at location pos (if i!=pos) Step 5: Repeat steps 3,4 by Increment pos to point to next element till n-1 until the list is sorted. Step 6: Stop.

Program Code: Selection sort with dynamic memory allocation

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

void selectionsort(int a[], int n) {
   int i, j, temp, pos;

   for(i = 0; i < n; i++) {
      pos = i;

      for(j = i+1; j < n; j++) {

         if(a[j] < a[pos]) {
            pos = j;
         }

         if(i != pos) {
            temp = a[i];
            a[i] = a[pos];
            a[pos] = temp;
         }
      }
   }
}

void main() {
   int i, n, *a;

   printf("Enter the array size: ");
   scanf("%d", &n);

   a = (int *) malloc (sizeof(int) * n);

   printf("\nEnter the array elements: ");
   for(i = 0; i < n; i++)
      scanf("%d", &a[i]);

   selectionsort(a, n);

   printf("\nThe sorted array is: ");
   for(i = 0; i < n; i++)
      printf("%d\n", a[i]);
}
```

Ex : 2

Title: Design, develop, and implement a data structure of integers that follows the LIFO principle and demonstrates its operations.

Problem Description: The program creates the data structure and performs operations like inserting an element, deleting an element, and displaying the status of the data structure
.

Method: In this program, create the data structure and support the program with appropriate functions for each of the above operations. Demonstrate Overflow and Underflow situations and support the program with appropriate functions for each of the above operations. When overflow occurs increase the size of the data structure by array doubling technique.

Theory Reference: Module 1

Explanation:

1. Dynamic Memory Allocation:
o The array a is dynamically allocated using malloc(). The size of the array is determined at runtime based on user input (max).
o The array a is dynamically is also reallocated using realloc() with size 2*max.
2. Basic stack operations
A stack is a linear data structure that follows the Last In, First Out (LIFO) principle, meaning the last element added to the stack is the first one to be removed.

Basic stack operations:

Push Operation - Adds an element to the top of the stack

Pop Operation - Removes and returns the top element from the stack.

3. Handling of stack overflow and underflow conditions - Stack is also resized in case of overflow using array doubling technique.
4. Freeing Memory: The dynamically allocated memory is freed using free() to avoid memory leaks.

Algorithm

Step 1: Initialize

1. Set top = -1 to indicate the stack is empty.
2. Allocate memory for the stack a with size max using malloc.

Step 2: Push Operation

1. Check if the stack is full:
   o If top == max - 1, it means the stack is full.
   o Double the size of the stack (max = 2 * max) and resize the stack using realloc.
   o Print a message indicating the stack has been resized.
2. Push the element:
   o Increment top by 1.
   o Insert the element ele at position a[top].

Step 3: Pop Operation

1. Check if the stack is empty:
   o If top == -1, print a message indicating "stack underflow" and return -999.
2. Pop the element:
   o Return the element at a[top].
   o Decrement top by 1.

Step 4: Display Operation

1. Check if the stack is empty:
   o If top == -1, print "stack is empty."
2. Display the stack elements:
   o Print all elements from a[top] to a[0].

Step 5: Main Loop

1. Initialize stack size:
   o Ask the user to input the initial value of max and allocate memory for the stack a using malloc.
2. Loop through the menu:
   o Print the menu and ask the user to enter a choice.
   o Based on the user's choice, call the corresponding function:
   ▪ Choice 1: Call push() to push an element onto the stack.
   ▪ Choice 2: Call pop() to remove and display the top element.
   ▪ Choice 3: Call display() to print all elements in the stack.
   ▪ Choice 4: Exit the program and free the allocated memory.
   o If the user enters an invalid choice, print "invalid choice."

Step 6: Terminate

• When the user chooses to exit, free the allocated memory for the stack and terminate the program

Program Code: Stack and its Operations

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

int max, *a, top = -1;

void push(int ele);
int pop();
void display();

void main() {
   int choice, ele;

   printf("Enter the size of the stacks: ");
   scanf("%d", &max);

   a = (int *) malloc (sizeof(int) * max);

   while(1) {
      printf("\nEnter your choice: ");
      printf("\n1: Push\t2: Pop\t3: Display\t4: Exit\n");
      scanf("%d", &choice);

      switch(choice) {
         case 1: printf("Enter the element to insert: "); scanf("%d", &ele); push(ele); break;

         case 2: ele = pop(); if(ele == -99) printf("Deleted element is: %d", ele); break;

         case 3: display(); break;

         case 4: free(a); exit(0);

         default: printf("Invalid input");
      }
   }
}

void push(int ele) {
   if(top == max-1) {
      printf("Stack Overflow");
      printf("\tDoubling the size...");
      a = realloc(a, 2 * max * sizeof(int));
   }

   top++;
   a[top] = ele;
}
```

```
int pop() {
    int ele;
    if(top == -1) {
        printf("Stack Underflow");
        return -99;
    }

    else {
        ele = a[top];
        top--;

        return ele;
    }
}

void display() {
    int i;
    if(top == -1) {
        printf("Stack Underflow");
    }

    else {
        printf("\nThe Stack elements are: \n");
        for(i = top; i >= 0; i--) {
            printf("%d", a[i]);
        }
    }
}
```

Ex : 3

Title: Design, Develop and Implement a Program in C for converting an Infix Expression to Postfix Expression and Evaluatethe converted postfix expression.

Problem Description: The problem involves implementing a function that convert the Infix Expression to Postfix Expression anda function that evaluates the converted expression and prints the result. Program should support for both parenthesized and free parenthesized expressions with the operators: +, -, *, /, % (Remainder), ^ (Power) and alphanumeric operands.

Method: In this program, Infix expression is given as an input andthe function for converting infix to postfix expression. After obtaining the postfix expression for each alphanumeric operand's values are given at the runtime and display the resultant value.

Choose the best data structure for these operations.

Theory Reference: Module 2

Explanation

1. **Define the precedence of operators:**

   Define the precedence levels for operators like `+`, `-`, `*`, `/`, `%`, and `^`. Higher precedence operators should be placed above lower precedence ones.

2. **Convert the Infix to Postfix:**

   We use a stack to convert the infix expression (which may have parentheses) into a postfix expression.

3. **Evaluate the Postfix expression:**

   Use a stack to evaluate the postfix expression. Each operand is pushed onto the stack, and operators pop the required number of operands to perform the operation, pushing the result back onto the stack.

4. **Handle Parentheses:**

Parentheses should control the precedence of operators and should be handled properly during both conversion and evaluation.

5. **Support for Alphanumeric Operands:**

   Alphanumeric operands should be stored directly in the postfix expression. During evaluation, variables need to be given a value or assumed.

Algorithm

Step 1: Initialize:

- tos = -1, top = -1
- istack[] for operators, stack[] for operands.

Step 2: Convert Infix to Postfix:

- Push '(' onto istack and add ')' to the end of Q.
- For each character in the infix expression:
  - If operand (alphanumeric), add to postfix.
  - If (, push to istack.
  - If), pop and append to postfix until (is found, then pop (.
  - If operator:
    - While precedence of operator <= precedence of top of stack, pop and append to postfix.
    - Push operator to stack.
- After scanning all characters, pop remaining operators from istack and append to postfix.

Step 3: Evaluate Postfix:

- For each character in postfix:
  - If operand:
    - Prompt for value and push to stack.

    - If operator:
        - Pop top two values from stack, perform operation, push result back.
- Pop and display final result.

Step 4: Main Execution

- Prompt the user to **input an infix expression**.
- **Convert the infix expression to a postfix expression** using the convertip() function.
- Display the **converted postfix expression**.
- **Evaluate the postfix expression** using the evaluate() function and display the result.

Step 5: Stop

Program Code: Infix to Postfix to Infix to Evaluation to Answer

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

char istack[20];
float stack[20];
int tos = -1;
int top = -1;

void ipush(char s)
{
   tos++;
   istack[tos] = s;
}

void push(float ele)
{
   top++;
   stack[top] = ele;
}

char ipop()
{
   // int ele = istack[tos];
   // tos--;
   return istack[tos--];
}

float pop()
{
   // float ele = stack[top];
   // top--;
   return stack[top--];
}
```

```
int precd(char s) {
   switch(s) {
      case '^': return 4;
      case '*':
      case '/':
      case '%': return 3;
      case '+':
      case '-': return 2;
      case '(':
      case ')':
      case '#': return 1;
   }
   return 0;
}

void convertip(char infix[20], char postfix[20]) {
   int i, j = 0;
   char symbol;
   ipush('#');
            for(i = 0; i < strlen(infix); i++) {
                  symbol = infix[i];
                  switch (symbol)
      {
      case '(': ipush(symbol);
         break;
      case ')':
         while(istack[tos] != '(')
            postfix[j++] = ipop();
            ipop();
            break;
      case '^':
      case '*':
      case '/':
      case '%':
      case '+':
      case '-':
         while(precd(symbol) <= precd(istack[tos]))
         postfix[j++] = ipop();
         ipush(symbol);
         break;

      default: postfix[j++] = symbol;
      }
   }
```

```
    while(istack[tos] != '#')
    postfix[j++] = ipop();

    postfix[j] = '\0';
}

void evaluate(char postfix[50]) {
    int i;
    char symbol;
    float op1, op2, result, x;
        for(i = 0; i < strlen(postfix); i++) {
                symbol = postfix[i];

        if(isalpha(symbol)) {
                printf("Enter the value for %c: \t", symbol);
                scanf("%f", &x);
                push(x);
} else {
          op2 = pop();
          op1 = pop();

          switch(symbol) {
             case '+':
                  push(op1+op2); break;
             case '-':
                  push(op1-op2); break;
             case '*':
                  push(op1*op2); break;
             case '/':
                  push(op1/op2); break;
             case '%':
                  push((int)op1%(int)op2); break;
             case '^':
                  push(pow(op1, op2)); break;
             default: printf("Invalid postfix expression.");
                  exit(0);
          }
       }
    }

    result = pop();
    printf("The result is: %f", result);
}
```

```
void main() {
   char infix[20], postfix[20];

   printf("Enter infix expression: ");
   gets(infix);

   convertip(infix, postfix);
   printf("Postfix expression is: %s", postfix);

   evaluate(postfix);
}
```

Part A

Ex : 4

Title: Design, develop, and implement an efficient use of memory data structure of Integers that follows the FIFO principle and demonstrates its operations.

Problem Description: The program creates the data structure and performs operations like inserting an element, deleting an element, and displaying the status of the data structure.

Method: In this program, create the data structure and support the program with appropriate functions for each of the above operations. Demonstrate Overflow and Underflow situations and support the program with appropriate functions for each of the above operations.

Theory Reference: Module 2

Explanation:

1. **Dynamic Memory Allocation:**
   - The size of the array (queue) is determined at runtime based on user input (max).
   - The array q is dynamically allocated using malloc().
2. **Queue Data Structure:**
   - A queue is a linear data structure that follows the First In, First Out (FIFO) principle, meaning the first element added to the queue is the first one to be removed.
   - Basic queue operations:
     - Enqueue Operation - Adds an element to the rear end of the queue.
     - Dequeue Operation - Removes and returns the element at the front end of the queue.
3. **Handling of queue overflow and underflow conditions:**
   - Relevant messages are displayed in case of queue overflow or underflow.
4. **Freeing Memory:**
   - The dynamically allocated memory is freed using free() to avoid memory leaks.

Algorithm:

Step 1: Initialize

i. Allocate memory for the queue q with size max using malloc.

ii. Set rear = -1, front = 0, count = 0 to indicate the queue is empty.

Step 2: Enqueue Operation

1. Check if the queue is full:
   - If count == max, it means the queue is full.
   - Print a message indicating overflow error.
2. Insert the element:
   - Increment rear by 1 (modulo addition).
   - Insert the element ele at position a[rear].
   - Increment count by 1.

Step 3: Dequeue Operation

1. Check if the queue is empty:
   - If count == 0, print a message indicating "Queue underflow".
2. Delete the element:
   - Print the deleted element, the element at q[front].
   - Increment front by 1 (modulo addition).

Step 4: Display Operation

1. Check if the queue is empty:
   - If count == 0, print "Queue is empty."
2. Display the queue elements:

- Print ‘count’ number of elements from q[front], using modulo addition for index incrementing.

Step 5: Main Function

1. Initialize queue size:
    - Ask the user to input the initial value of max and allocate memory for the queue q using malloc.
2. Loop through the menu:
    - Print the menu and ask the user to enter a choice.
    - Based on the user's choice, call the corresponding function:
        - Choice 1: Call Enqueue() to insert an element into the queue.
        - Choice 2: Call Dequeue() to delete and display the deleted element.
        - Choice 3: Call display() to print all elements in the queue.
        - Choice 4: Exit the program and free the allocated memory.
    - If the user enters an invalid choice, print "Invalid choice."

Step 6: Terminate

- When the user chooses to exit, free the allocated memory for the queue and terminate the program.

Program Code: Queue and its operations

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

int rear = -1;
int front = 0;
int max;
int count = 0;
int *q;

void dequeue() {
   int ele;

   if(count == 0) {
      printf("Queue Underflow");
   }
   else {
      ele = q[front];

      front = (front + 1) % max;
      count--;

      printf("\nDeleted element is: %d", ele);
   }
}

void display() {
   int i, k;

   if(count == 0) {
      printf("Queue is empty");
   }
   else {
      printf("\nThe Queue elements are: \n");
      k = front;

      for(i = 0; i < count; i++) {
         printf("%d\t", q[k]);
         k = (k + 1) % max;
      }
   }
}
```

```
void enqueue() {
   int ele;

   if(count == max)
      printf("Queue Overflow");

   else {
   printf("\nEnter element to be inserted: ");
   scanf("%d", &ele);

   rear = (rear + 1) % max;
   q[rear] = ele;
   count++;
   }
}



void main() {
   int i, ele, choice;

   printf("Enter max queue size: ");
   scanf("%d", &max);

   q = (int *) malloc (sizeof(int) * max);

   while(1) {
      printf("\nEnter your choice: \n1: Enqueue\t2: Dequeue\t3: Display\t4: Exit");
      scanf("%d", &choice);

      switch(choice) {
         case 1: enqueue(); break;

         case 2: dequeue(); break;

         case 3: display(); break;

         case 4: free(q); exit(0);

         default: printf("Invalid input");
      }
   }
}
```

Ex : 5

Title: Design, Develop and Implement a menu driven Program in C for handling change of branch.

Problem Description: After 1st year, students can apply for change of branch and are generally selected based on their CGPA. Assume that among the selected students, some may change their mind. Some existing students also may choose to leave and join another department. Display the complete student data with regular and change of branch students, Limit your program to only your department.

Method: Make use of arrays and linked lists.

Theory Reference: Module 3

Explanation:

1. **Data Structure:**
   - The list of students can be implemented as a singly linked list.
   - To represent a node of a singly linked list in C, a structure can be used that has four data members usn, name, mode and next where:

     usn: indicates the USN of the student.

     name: indicates the name of the student.

     mode: indicates the mode of the student(Regular/Lateral/COB/COC)

     next: is a pointer that will store the address of the next node in the sequence.
2. **Singly Linked List**

   A singly linked list is a type of linked list where only the address of the next node is stored in the current node along with the data field and the last node in the list contains NULL pointer. This makes it impossible to find the address of the particular node in the list without accessing the node previous to it. So we can only access the data sequentially in the node.

   Basic list operations:

   i. Create a list – Creates the first node in the list called start.

ii. Insert at the end of the list – inserts a node to the end of the list.

iii. Delete a node from the list – deletes the node whose usn == key, the value of key is entered by the user.

iv. Display the list – Displays the USN and mode (Regular/Lateral/COC/COB) of all the students in the class

3. **Freeing Memory:** The dynamically allocated memory is freed using free() to avoid memory leaks.

Algorithm:

Step 1: Initialize

- Define a self-referential node.
- Create the first node in the list called start (by dynamic memory allocation function, malloc()) and assign the USN of the first student.

Step 2: Insert at the end of the singly linked list.

- Create a new Node.
- If the list is empty, update the start pointer to be this new node and then return.
- Otherwise traverse till the last node of the singly linked list.
- Connect next pointer of the last node to the new node.

Step 3: Delete a node in the singly linked list, whose usn == key.

- Ensure that the Head of the linked list is not NULL; if it is, the list is empty, so return.
- If the singly linked list has only one node, delete the head node and point the head pointer to NULL.
- Traverse till the node whose usn == key is found.
- Use a second pointer to track the previous node to the current node.
- Connect the next node of the current node as the next node of the previous node.

- Delete (free) the current node represented by the temporary pointer.

Step 4: Display Operation

- Check if the HEAD of the singly linked is is NULL or not. If NULL return back.
- Set a temp pointer to the head of the singly linked list.
- While temp pointer != NULL:
- Print temp->data.
- Move temp to temp->next

Step 5: Main Function

1. **Initialize the singly linked list.**
   - Ask the user to input the number of students.
   - Create the list with the details of the first student.
   - Add the remaining students by inserting at the end of the list.
2. **Loop through the menu:**
   - Print the menu and ask the user to enter a choice.
   - Based on the user's choice, call the corresponding function:
     - Choice 1: Call insertend() to initialize the list of regular students.
     - Choice 2: Call display() to print the details of all the students in the class.
     - Choice 3: Call deletekey() to delete the details of the student whose USN matches the key, entered by the user.
     - Choice 4: Call insertend() to add the details of Lateral/COC/COB students.
     - Choice 5: Exit the program and free the allocated memory.
   - If the user enters an invalid choice, print "invalid choice."

Step 6: Terminate

- When the user chooses to exit, free the allocated memory for the stack and terminate the program.

Program Code: Change of Branch

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

struct SLL {
   int usn;
   char name[20];
   char mode[20];
   struct SLL *next;
};

typedef struct SLL node;
node *start = NULL;

node *createNode();
void insertEnd();
void display();
void deleteKey();


void main() {
   int i, n, choice, ele;

   while(1) {
      printf("Enter your choice: ");
      printf("1: Insert\t2: Display\t3: Delete\t4: Add to branch\t5: Exit\n");
      scanf("%d", &choice);

      switch(choice) {
         case 1:
         case 4: printf("Enter number of students: \n");
         scanf("%d", &n);
         for(i = 0; i < n; i++) {
            insertEnd();
         } break;

         case 2: display(); break;

         case 3: deleteKey(); break;

         case 5: exit(0);

         default: printf("Invalid choice");
      }
   }
}
```

```
node *createNode() {
   node *newnode;

   newnode = (node *) malloc (sizeof(node));
   printf("Enter USN | Name | Mode: ");
   scanf("%d %s %s", &newnode->usn, newnode->name, newnode->mode);

   newnode->next = NULL;

   return newnode;
}


void display() {
   node *temp = start;

   if(start == NULL) {
      printf("List empty, cant delete");
      return ;
   }

   printf("Students in class are: \n");

   while(temp != NULL) {
   printf("USN: %d\tName: %s\tMode: %s\n", temp->usn, temp->name, temp->mode);
   temp = temp->next;
   }
}

void insertEnd() {
   node *newnode, *temp;

   newnode = createNode();
   if(start == NULL) {
      start = newnode;
      return;
   }

   temp = start;
   while(temp->next != NULL) {
      temp = temp->next;
   }

   temp->next = newnode;
}
```

```
void deleteKey() {
    node *temp = start, *prev;
    int key;

    if(start == NULL) {
        printf("\nList is empty, cant delete");
    }
    printf("Enter key: ");
    scanf("%d", &key);

    if(start->usn == key) {
        start = start->next;
        printf("deleted: %d", temp->usn);
        free(temp);
    }

    else {
        while(temp != NULL && temp->usn != key) {
            prev = temp;
            temp = temp->next;
        }

        if(temp == NULL) {
            printf("USN invalid");
            return;
        }

        prev->next = temp->next;
        printf("Deleted element is: %d", temp->usn);
        free(temp);
    }
}
```

Ex : 6

Title: Design, Develop and Implement a menu driven Programin C for traversing a tree and search a given item.

Problem Description: Create a hierarchical data structure and perform efficient insertion and search.

Given a set of data items,

Create a hierarchical data structure of N nodes, with certain order.Implement all Traversal of the created data structure and output the nodes visited.

Iii) Perform efficient Search for an element (KEY) in the created data structure and report the appropriate message.

Method: Make use of binary search tree. You can use recursion or iterative techniques.

Theory Reference: Module 4

Explanation:

Hierarchical Data Structure: The program creates a binary search tree, where each node contains a data item, and links to its left and right children.

Efficient Insertion: Nodes are inserted into the tree while maintaining the properties of the BST, where left children are less than the parent node, and right children are greater.

Tree Traversals: The program supports three types of tree traversals:

- **Inorder Traversal**: Visits nodes in left-root-right order, yielding sorted output.
- **Preorder Traversal**: Visits nodes in root-left-right order.
- **Postorder Traversal**: Visits nodes in left-right-root order.

Search Functionality: Users can search for a specific key in the BST and receive feedback on whether the key exists.

Algorithm:

Step 1: Initialize

Define a self-referential node.

Define a structure BST with the following fields:

- data: an integer to store the value of the node.
- left: a pointer to the left child node.
- right: a pointer to the right child node.

```
struct BST
{
        int data;
        struct BST *left;
        struct BST *right;
};
```

Step 2. Insertion Function

- **Function**: insert(node *root, int key)
    1. If root is NULL, allocate memory for a new node, set its data to key, and set left and right to NULL.
    2. If key is less than root->data, recursively call insert on the left child.
    3. If key is greater than root->data, recursively call insert on the right child.
    4. Return the root.

3. Inorder Traversal Function

- **Function**: inorder(node *root)
    1. If root is not NULL, recursively call inorder on the left child.
    2. Print root->data.

3. Recursively call inorder on the right child.

4. Preorder Traversal Function

- **Function**: preorder(node *root)
    1. If root is not NULL, print root->data.
    2. Recursively call preorder on the left child.
    3. Recursively call preorder on the right child.

5. Postorder Traversal Function

- **Function**: postorder(node *root)
    1. If root is not NULL, recursively call postorder on the left child.
    2. Recursively call postorder on the right child.
    3. Print root->data.

6. Search Function

- **Function**: search(node *root, int key)
    1. If root is NULL, print "key not found".
    2. If root->data equals key, print "key found".
    3. If key is less than root->data, recursively call search on the left child.
    4. If key is greater, recursively call search on the right child.

7. Main Function

- **Function**: main()
    1. Declare variables for the number of nodes, key, and user choice.
    2. Initialize root as NULL.
    3. Prompt the user to enter the number of nodes (n).
    4. Loop n times to read node values and insert them into the BST.
    5. Enter an infinite loop to display a menu for tree operations:

- If the user chooses:
  - 1: Perform and print the result of the inorder traversal.
  - 2: Perform and print the result of the preorder traversal.
  - 3: Perform and print the result of the postorder traversal.
  - 4: Prompt for a key and search for it in the BST.
  - 5: Exit the program.
  - Any other input: Print "invalid choice".

Program code:

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

struct BST {
   int data;
   struct BST *left, *right;
};

typedef struct BST node;

node *insert(node *root, int key) {
   if(root == NULL) {
      root = (node *) malloc (sizeof(node));
      root->data = key;
      root->left = root->right = NULL;
      return root;
   }
   if(key < root->data)
      root->left = insert(root->left, key);
   else
      root->right = insert(root->right, key);
   return root;
}

void inorder(node *root) {
   if(root != NULL) {
      inorder(root->left);
      printf(" %d", root->data);
      inorder(root->right);
   }
}

void preorder(node *root) {
   if(root != NULL) {
      printf(" %d", root->data);
      preorder(root->left);
      preorder(root->right);
   }
}

void postorder(node *root) {
   if(root != NULL) {
     postorder(root->left);
     postorder(root->right);
     printf(" %d", root->data);
   }
}
```

```
void search(node *root, int key) {

   if(root == NULL) {
      printf("Key not found"); return;
   }

   if(root->data == key) {
      printf("Key found"); return;
   }

   if(key < root->data) {
      search(root->left, key);
   }
   else
      search(root->right, key);
}

void main() {
   int n, i, key, choice;

   node *temp, *root = NULL;
   printf("Enter number of nodes: ");
   scanf("%d", &n);

   printf("Enter elements: ");
   for(i = 0; i < n; i++) {
      scanf("%d", &key);
      root = insert(root, key);
   }

   while(1) {
      printf("\nEnter choice: ");
      printf("\n1: Inorder\t2: Preorder\t3: Postorder\t4: Search\t5: Exit\n");
      scanf("%d", &choice);

      switch(choice) {

         case 1:
         printf("\nInorder: ");
         inorder(root); break;

         case 2:
         printf("\nPre-order: ");
         preorder(root); break;

         case 3:
         printf("\nPost-order: ");
         postorder(root); break;
```

```
            case 4:
            printf("Enter search element: ");
            scanf("%d", &key);
            search(root, key); break;

            case 5: exit(0);

            default: printf("Invalid choice!");
        }
    }
}
```

Ex : 7

Title: Develop a C program to implement height balanced tree.

Problem Description: Given an imbalanced tree, restructure itas a balanced tree.

Method: Make use of AVL tree.

Ensure that the program performs proper rotations such as Left-Left, LR, RR and RL to create a height balanced binary search tree and display the tree created as a output .

Theory Reference: Module 4

Explanation:

1. Struct Definition (struct AVL)

   - int key: The value of the node.
   - struct AVL *left: Pointer to the left child node.
   - struct AVL *right: Pointer to the right child node.
   - int height: The height of the node, which is used to maintain the balance of the AVL tree.

2. Function: getHeight(node *n)

   - Returns the height of the node n.

3. Function: createNode(int key)

   - Allocates memory for a new node and initializes its values.

4. Function: max(int a, int b)

   - Returns the maximum of two integers.

5. Function: getBalanceFactor(node *n)

   - Computes the balance factor of a node.

6. Function: rightRotate(node *y)

   - Performs a right rotation around node y.

7. Function: leftRotate(node *x)

- Performs a left rotation around node x.

8. Function: insert(node *n, int key)

- Inserts a new key into the AVL tree while maintaining its balance.

9. Function: printtree(node *root, int space, int n)

- Prints the AVL tree in a structured format for visualization.

Algorithm:

Step 1. getHeight(node *n)

- Input: A pointer to a node n.
- If n is NULL, return 0.
- Otherwise, return the height of the node (n->height).

Step 2. createNode(int key)

- Input: An integer key.
- Allocate memory for a new node.
- Set the node's key to the given key.
- Initialize the left and right pointers to NULL.
- Set the height to 1 (new node).
- Return the pointer to the newly created node.

Step 3. max(int a, int b)

- Input: Two integers a and b.
- Return the larger of the two values.

Step 4. getBalanceFactor(node *n)

- Input: A pointer to a node n.
- If n is NULL, return 0.
- Calculate the balance factor as the height of the left subtree minus the height of the right subtree (getHeight(n->left) - getHeight(n->right)).
- Return the balance factor.

Step 5. rightRotate(node *y)

- Input: A pointer to a node y (the root of the subtree).
- Set x to the left child of y.
- Set T2 to the right child of x.
- Perform the rotation:
  - Set x->right to y.
  - Set y->left to T2.
- Update the heights of x and y.
- Return x (new root of the subtree).

Step 6. leftRotate(node *x)

- Input: A pointer to a node x (the root of the subtree).
- Set y to the right child of x.
- Set T2 to the left child of y.
- Perform the rotation:
  - Set y->left to x.
  - Set x->right to T2.
- Update the heights of y and x.
- Return y (new root of the subtree).

Step 7. insert(node *n, int key)

- Input: A pointer to a node n and an integer key.
- If n is NULL, create and return a new node with the given key.
- If key is less than n->key, recursively insert in the left subtree.
- If key is greater than n->key, recursively insert in the right subtree.
- Update the height of n.
- Calculate the balance factor of n.
- Check for and perform necessary rotations based on the balance factor:
  - **Left Left Case**: Perform right rotation.
  - **Right Right Case**: Perform left rotation.
  - **Left Right Case**: Perform left rotation on the left child, then right rotation on n.
  - **Right Left Case**: Perform right rotation on the right child, then left rotation on n.
- Return the root n.

Step 8. printtree(node *root, int space, int n)

- Input: A pointer to the root node, an integer space, and an integer n.
- If root is NULL, return.
- Increment space by n.
- Recursively print the right subtree.

- Print the current node's key with appropriate indentation based on space.
- Recursively print the left subtree.

Step 9. main()

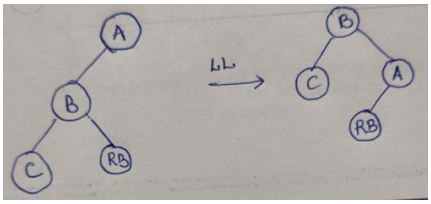
- Declare a pointer root initialized to NULL.
- Read the number of nodes n from user input.
- Loop n times:
  - Read an integer key from user input.
  - Insert the key into the AVL tree by calling insert(root, key).
- Print the tree structure by calling printtree(root, 0, n).
- Return 0.

Module -4 – AVL Tree

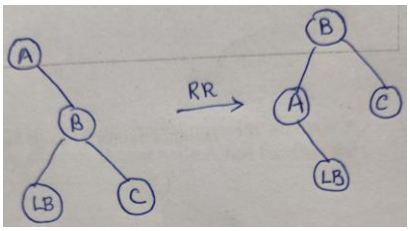
AVL Tree Implementation

Implementation 1(as done in class):

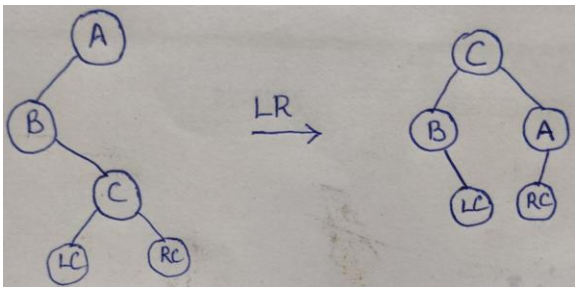
```
/*   Program - AVL Tree Implementation */
#include <stdio.h>
#include <stdlib.h>
struct AVL
{
   int key;
   struct AVL *left;
   struct AVL *right;
   int height;
};
typedef struct AVL node;
int getHeight(node *n)
{
   if(n==NULL)
      return 0;
   return n->height;
}
node *createNode(int key)
{
   node* n = (node *) malloc(sizeof(node));
   n->key = key;
   n->left = NULL;
   n->right = NULL;
   n->height = 1;
   return n;
}
int max (int a, int b)
{
   return (a>b)?a:b;
}
int getBalanceFactor(node * n)
{
   if(n==NULL)
      return 0;
   return getHeight(n->left) - getHeight(n->right);
}
node* leftRotate(node* A)
{
   node* B = A->left;
   node* RB = B->right;
   B->right = A;
   A->left = RB;
```



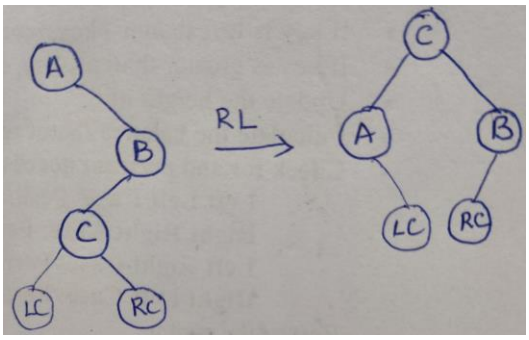
```
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   return B;
}
node* rightRotate(node* A)
{
   node* B = A->right;
   node* LB = B->left;
   B->left = A;
   A->right = LB;
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   return B;
}
```




```
node* leftrightRotate(node* A)
{
   node* B = A->left;
   node* C = B->right;
   node* LC = C->left;
   node* RC = C->right;
   C->left = B;
   C->right = A;
   B->right = LC;
   A->left = RC;
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   C->height = max(getHeight(C->right), getHeight(C->left)) + 1;
   return C;
}
```




```
node* rightleftRotate(node* A)
{
   node* B = A->right;
   node* C = B->left;
   node* LC = C->left;
   node* RC = C->right;
   C->left = A;
   C->right = B;
   A->right = LC;
   B->left = RC;
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   C->height = max(getHeight(C->right), getHeight(C->left)) + 1;
   return C;
}
```

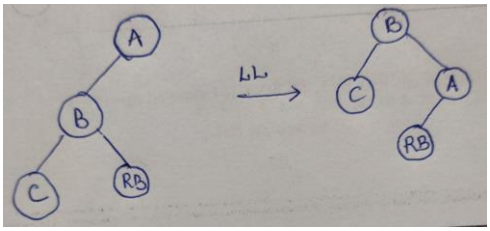


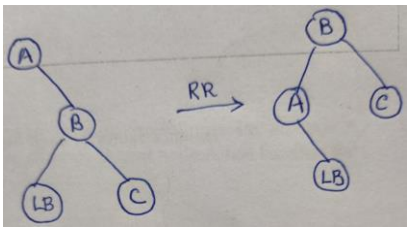

```
node *insert(node* n, int key)
{       int bf;
        if (n == NULL)
```

```
                return  createNode(key);
        if (key < n->key)
                n->left  = insert(n->left, key);
        else if (key > n->key)
                n->right = insert(n->right, key);
        n->height = 1 + max(getHeight(n->left), getHeight(n->right));
        bf = getBalanceFactor(n);
        // Left Left Case
        if(bf>1 && key < n->left->key)
                return leftRotate(n);
        // Right Right Case
        if(bf<-1 && key > n->right->key)
                return rightRotate(n);
        // Left Right Case
        if(bf>1 && key > n->left->key)
                return leftrightRotate(n);
        // Right Left Case
        if(bf<-1 && key < n->right->key)
                return rightleftRotate(n);
        return n;
}
void printtree(node *root, int space,int n)
{
        int i;
        if (root == NULL)
                return;
        space +=n;
        printtree(root->right, space,n);
        printf("\n");
        for (i =n; i < space; i++)
                printf(" ");
        printf("(%d)\n", root->key,space);
        printtree(root->left, space,n);
}
int main()
{
        node * root = NULL;
        int n,i,key;
        printf("enter the number of nodes\n");
        scanf("%d",&n);
        for(i=0;i<n;i++)
        {
                printf("enter the key\n");
                scanf("%d",&key);
                root = insert(root, key);
        }
        printtree(root, 0, n) ;
        return 0;
}
```

Implementation 2:

```
/*   Program - AVL Tree Implementation */
#include <stdio.h>
#include <stdlib.h>
struct AVL
{
   int key;
   struct AVL *left;
   struct AVL *right;
   int height;
};
typedef struct AVL node;
int getHeight(node *n)
{
   if(n==NULL)
      return 0;
   return n->height;
}
node *createNode(int key)
{
   node* n = (node *) malloc(sizeof(node));
   n->key = key;
   n->left = NULL;
   n->right = NULL;
   n->height = 1;
   return n;
}
int max (int a, int b)
{
   return (a>b)?a:b;
}
int getBalanceFactor(node * n)
{
   if(n==NULL)
        return 0;
   return getHeight(n->left) - getHeight(n->right);
}
node* leftRotate(node* A)
{
   node* B = A->left;
   node* RB = B->right;
   B->right = A;
   A->left = RB;
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   return B;
}
```






```
node* rightRotate(node* A)
{
   node* B = A->right;
   node* LB = B->left;
   B->left = A;
   A->right = LB;
   A->height = max(getHeight(A->right), getHeight(A->left)) + 1;
   B->height = max(getHeight(B->right), getHeight(B->left)) + 1;
   return B;
}
node *insert(node* n, int key)
{
   int bf;
        if (n == NULL)
                return  createNode(key);
        if (key < n->key)
                n->left  = insert(n->left, key);
        else if (key > n->key)
                n->right = insert(n->right, key);
        n->height = 1 + max(getHeight(n->left), getHeight(n->right));
        bf = getBalanceFactor(n);
        // Left Left Case
        if(bf>1 && key < n->left->key)
                return leftRotate(n);
        // Right Right Case
        if(bf<-1 && key > n->right->key)
                return rightRotate(n);
        // Left Right Case
        if(bf>1 && key > n->left->key)
        {
                n->left = rightRotate(n->left);
                return leftRotate(n);
        }
        // Right Left Case
        if(bf<-1 && key < n->right->key)
        {
                n->right = leftRotate(n->right);
                return rightRotate(n);
        }
        return n;
}
void printtree(node *root, int space,int n)
{
int i;
        if (root == NULL)
                return;
        space +=n;
        printtree(root->right, space,n);
        printf("\n");
```

```
        for (i =n; i < space; i++)
                printf(" ");
        printf("(%d)\n", root->key,space);
        printtree(root->left, space,n);
}
int main()
{
        node * root = NULL;
        int n,i,key;
        printf("enter the number of nodes\n");
        scanf("%d",&n);
        for(i=0;i<n;i++)
        {
                printf("enter the key\n");
                scanf("%d",&key);
                root = insert(root, key);
        }
        printtree(root, 0, n) ;
        return 0;
}
```

Ex : 8

Title: Design, Develop and Implement a Program in C to create N router connections and display the routers by removal of which will disconnect the network completely.

Problem Description: create a data structure to represent the routers and its connections between the routers and display the router numbers on removal which it disconnects the network completely.

Method: choose the best data structure to represent the routers and a function to find the articulation point.

Theory Reference: Module 5

Explanation:

- **Articulation Point**: A vertex that, when removed, disconnects the graph.
- **DFS**: A traversal technique used to explore nodes and edges of a graph. The `dfnlow` function performs the main DFS operation while tracking discovery and low values.
- **dfn[u]**: Discovery time of vertex `u`.
- **low[u]**: The lowest discovery time reachable from `u`.
- **parent[u]**: The parent vertex of `u` in the DFS tree.
- **Adjacency Matrix**: The graph is represented as an adjacency matrix `adj`, where `adj[u][v]` is `1` if there's an edge between routers `u` and `v`.

Following Initializations are done:

- Arrays are initialized to keep track of:
  - Discovery times (`dfn`)
  - Low values (`low`)
  - Parent vertices (`parent`)
  - Visited vertices (`visited`)
  - Articulation points (`articulation`)

Algorithm:

Step 1: main Function - To initialize the graph and collect user input for the number of vertices and edges. Update the adjacency matrix to mark the edge between u and v as present (set adj[u][v] and adj[v][u] to 1).

Step 2: findArticulationPoints Function - To find articulation points in the graph using Depth-First Search (DFS).

1. For i=0 to V−1:
    - Initialize `parent[i]` to -1 (indicating no parent).
    - Initialize `visited[i]` to 0 (indicating not visited).
    - Initialize `articulation[i]` to 0 (indicating not an articulation point).
2. For i=0 to V−1:
    - If `visited[i]` is 0, call `dfnlow(i, adj, V)` to perform DFS from vertex i.
3. Print the articulation points:
    - For i=0 to V−1:
        - If `articulation[i]` is 1, print "Router i".

Step 3. dfnlow Function - To perform DFS and update dfn and low values, identifying articulation points.

1. Initialize `children` to 0 (to count child vertices of the current vertex u).
2. Mark `u` as visited: set `visited[u]` to 1.
3. Set `dfn[u]` and `low[u]` to `time` (incremented by 1).
4. For each vertex v from 0 to V−1:
    - If there is an edge from u to v (`adj[u][v] == 1`):
        - If v is not visited:
            1. Increment `children` by 1.
            2. Set `parent[v]` to u.
            3. Recursively call `dfnlow(v, adj, V)`.
            4. Update `low[u]`: set `low[u]` to the minimum of `low[u]` and `low[v]`.
            5. Check if u is an articulation point:
                - If u is the root of the DFS tree (i.e., `parent[u] == -1`) and has two or more children, mark u as an articulation point.
                - If u is not the root and `low[v] >= dfn[u]`, mark u as an articulation point.
        - Else if v is visited and v is not the parent of u:
            - Update `low[u]`: set `low[u]` to the minimum of `low[u]` and `dfn[v]`.

Program:

```
#include <stdio.h>
#include <stdlib.h>
#define MAX 100
int dfn[MAX],low[MAX],parent[MAX],time = 0;
int visited[MAX],articulation[MAX];
void dfnlow(int u, int adj[MAX][MAX], int V)
{
        int children = 0,v;
        visited[u] = 1;
        dfn[u] = low[u] = ++time;
        for (v = 0; v < V; v++)
        {
                if (adj[u][v])
                {
                        // If there's an edge between u and v
                        if (!visited[v])
                        {
                                children++;
                                parent[v] = u;
                                dfnlow(v, adj, V);
```

```
                    // Check if the subtree rooted at v has a connection back to one of the ancestors of u
                    low[u] = (low[u] < low[v]) ? low[u] : low[v];
                    // u is an articulation point in the following cases:
                    // Case 1: u is the root of DFS tree and has two or more children.
                    if (parent[u] == -1 && children > 1)
                    articulation[u] = 1;
                    // Case 2: u is not the root and low value of one of its children is more than dfn value of u.
                    if (parent[u] != -1 && low[v] >= dfn[u])
                    articulation[u] = 1;
                }
                else if (v != parent[u])
                {
                    // Update low value of u for parent function calls.
                    low[u] = (low[u] < dfn[v]) ? low[u] : dfn[v];
                }
            }
        }
}
void findArticulationPoints(int adj[MAX][MAX], int V)
{
        int i;
        for (i = 0; i < V; i++)
```

```
        {
                parent[i] = -1;
                visited[i] = 0;
                articulation[i] = 0;
        }
        for (i = 0; i < V; i++)
        {
                if (!visited[i])
                dfnlow(i, adj, V);
        }
        printf("Articulation points are:\n");
        for (i = 0; i < V; i++)
        {
                if (articulation[i])
                        printf("Router %d\n", i);
        }
}
int main()
{
        int V,E,i,adj[MAX][MAX] = {0},u,v;
        printf("Enter the number of routers (vertices): ");
```

```
    scanf("%d",&V);
    printf("Enter the number of connections (edges): ");
    scanf("%d",&E);
    printf("Enter the connections (u v):\n");
    for (i = 0; i < E; i++)
    {
        scanf("%d %d", &u,&v);
        adj[u][v] = 1;
        adj[v][u] = 1;
    }
    findArticulationPoints(adj, V);
    return 0;
}
```

Output:

```
Enter the number of routers (vertices): 10
Enter the number of connections (edges): 11
Enter the connections (u v):
0 1
1 2
1 3
2 4
3 4
3 5
5 7
5 6
6 7
7 8
7 9
Articulation points are:
Router 1
Router 3
Router 5
Router 7
```

Ex : 9

Title: Design, Develop and Implement a Program in C to perform polynomial addition, output the polynomial result and evaluate the resultant polynomial.

Problem Description: Read two polynomials and perform addition. Evaluate the resultant polynomial by providing x value.

Method: A Polynomial is a collection of terms, and each term consist of coefficient, variable and exponent. Represent it using structures. Consider the polynomial with one variable x, Input the vale of x to evaluate the resultant polynomial after addition.

Theory Reference: Module 1

Explanation:

The program defines a polynomial structure and implements functions to read, add, print, and evaluate polynomials.

Structure definition

```
struct polynomial
{
        int coeff; // Coefficient of the polynomial term
        int expo; // Exponent of the polynomial term
};
```

Algorithm:

Step 1: readpolynomial Function

Reads polynomial terms from user input.

Step 2: addpolynomial Function

1. Initialize three indices: i for p1, j for p2, and k for p3.
2. While both i and j are within bounds:
    - If the exponents of the current terms in both polynomials are equal:
        - Add their coefficients and store in p3.
        - Increment i, j, and k.
    - If the exponent of p1 is greater than that of p2:

        - Copy the term from p1 to p3.
        - Increment i and k.
    - If the exponent of p2 is greater:
        - Copy the term from p2 to p3.
        - Increment j and k.
3. After one of the polynomials is fully processed, add the remaining terms from the other polynomial.
4. Return the number of terms in the resultant polynomial.

Step 3: printpolynomial Function

1. Loop from 0 to n−2:
    - Print each term in the format coeff(x^expo) followed by a plus sign.
2. Print the last term without a plus sign.

Step 4: evaluate Function

1. Initialize sum to 0.
2. Prompt the user to enter the value of x.
3. Loop through each term in the polynomial:
    - Calculate the term's contribution as coeff * (x ^ expo).
    - Add this contribution to sum.
4. Print the result.

Step 5. main Function

1. Create three arrays to store the two input polynomials and the result.
2. Read the number of terms and coefficients/exponents for the first polynomial.
3. Read the number of terms and coefficients/exponents for the second polynomial.
4. Print both input polynomials.
5. Call `addpolynomial` to get the resultant polynomial.
6. Print the resultant polynomial.
7. Call `evaluate` to compute the value of the resultant polynomial at a user-defined x.

Program:

```
#include<stdio.h>
#include<math.h>
struct polynomial
{
   int coeff;
```

```
    int expo;
};
typedef struct polynomial poly;
void readpolynomial(poly p[], int n);
int addpolynomial(poly p1[], poly p2[], int n1, int n2, poly p3[]);
void printpolynomial(poly p[], int n);
void evaluate(poly p[],int n);
void readpolynomial(poly p[], int n)
{
    int i;
   for (i = 0; i < n; i++)
{
        printf("\n Enter the Coefficient and the Exponent");
        scanf("%d%d",&p[i].coeff,&p[i].expo);
    }
}
int addpolynomial(poly p1[], poly p2[], int n1, int n2, poly p3[])
{
    int i=0, j=0, k=0;
    while (i < n1 && j <n2)
   {
          if (p1[i].expo == p2[j].expo)
          {
          p3[k].coeff = p1[i].coeff + p2[j].coeff;
                    p3[k].expo = p1[i].expo;
                    i++;
                    j++;
                    k++;
        }
```

```
      else if (p1[i].expo > p2[j].expo)
      {
                  p3[k]=p1[i];
                  i++;
                  k++;
       }
       else
          {
                  p3[k] = p2[j];
                  j++;
                  k++;
       }
    }
    while (i < n1)
    {
       p3[k] = p1[i];
       i++;
       k++;
     }
   while (j < n2)
  {
        p3[k] = p2[j];
          j++;
        k++;
    }
    return (k);
}
void printpolynomial(poly p[], int n)
{
```

```
    int i;
    for (i = 0; i < n - 1; i++)
        printf("%d(x^%d)+", p[i].coeff, p[i].expo);
    printf("%d(x^%d)", p[n - 1].coeff, p[n - 1].expo);
}
void evaluate(poly p[],int n)
{
        int sum=0,i,x;
        printf("\n enter the value of x:");
        scanf("%d",&x);
        for (i = 0; i < n; i++)
                sum=sum+p[i].coeff*pow(x,p[i].expo);
        printf("\n Result=%d\n",sum);
}
int main()
{
        int n1, n2, n3;
        poly p1[10],p2[10],p3[10];
        printf("enter number of terms in first polynomial");
        scanf("%d",&n1);
        readpolynomial(p1,n1);
        printf("enter number of terms in second polynomial");
        scanf("%d",&n2);
        readpolynomial(p2,n2);
        printf(" \n First polynomial : ");
        printpolynomial(p1, n1);
        printf(" \n Second polynomial : ");
        printpolynomial(p2, n2);
        n3 = addpolynomial(p1,p2,n1,n2,p3);
```

```
    printf(" \n Resultant polynomial after addition : ");
    printpolynomial(p3, n3);
    evaluate(p3, n3);
    return 0;
}
```

Output

```
enter number of terms in first polynomial3

 Enter the Coefficient and the Exponent2 2

 Enter the Coefficient and the Exponent3 1

 Enter the Coefficient and the Exponent5
0
enter number of terms in second polynomial3

 Enter the Coefficient and the Exponent2 2

 Enter the Coefficient and the Exponent3 1

 Enter the Coefficient and the Exponent5 0

 First polynomial : 2(x^2)+3(x^1)+5(x^0)
 Second polynomial : 2(x^2)+3(x^1)+5(x^0)
 Resultant polynomial after addition : 4(x^2)+6(x^1)+10(x^0)
 enter the value of x:2

 Result=38

--------------------------------
Process exited after 46.87 seconds with return value 0
Press any key to continue . . .
```

Ex : 9b

Title: Design, Develop and Implement a Program in C to read a sparse matrix to search a particular value and to display the transpose of the matrix in its triplet format.

Problem Description: To manage sparse matrices using a triplet representation and finding its transpose.

Method: The Program must allow the user to read a sparse matrix, display it in triplet format, search for specific values, and transpose the matrix.

Theory Reference: Module 1

Explanation:

Structure Definition

```
struct sparse
{
    int row; // Row index of the non-zero element
    int col; // Column index of the non-zero element
    int val; // Value of the non-zero element
} s[10];
```

This structure represents a non-zero element of a sparse matrix, storing its row index, column index, and value. An array s of this structure is used to store the matrix.

Algorithm:

Step 1: readsparsematrix Function

Reads a sparse matrix from user input and stores its non-zero elements in triplet form.

Step 2: triplet Function

Displays the triplet representation of the sparse matrix.

Step 3: search Function

Searches for a specified key (value) in the sparse matrix.

1. Prompt the user to enter a value `key` to search for.
2. Initialize a flag `found` to 0.
3. Loop from `1` to `s[0].val`:
    - If `s[i].val` matches the `key`:
        - Print the row and column of the found element.
        - Set `found` to 1 and break the loop.
4. If `found` is still 0 after the loop, print "element not found."

Step 4: transpose Function

1. Create a temporary structure array `trans` to store the transposed matrix.
2. Set the dimensions of the transposed matrix:
    - `trans[0].row` = `s[0].col` (new number of rows)
    - `trans[0].col` = `s[0].row` (new number of columns)
    - `trans[0].val` = `s[0].val` (same number of non-zero elements)
3. Initialize a variable `k` to 1 to index into the transposed array.
4. Loop over each column iii of the original matrix:
    - For each non-zero element in `s`:
        - If the column index matches iii:
            - Assign the transposed values:
                - `trans[k].row` = `s[j].col`
                - `trans[k].col` = `s[j].row`
                - `trans[k].val` = `s[j].val`
            - Increment `k`.
5. Copy the transposed matrix back to `s` (overwriting the original).
6. Call `triplet()` to display the transposed matrix.

Step 5: main Function

1. Call `readsparsematrix()` to read the sparse matrix from user input.
2. Call `triplet()` to display the original sparse matrix.
3. Call `search()` to allow the user to search for a specific value in the matrix.
4. Call `transpose()` to compute and display the transposed matrix.

Program:

```
#include <stdio.h>
struct sparse
{
   int row;
   int col;
   int val;
} s[10];
void readsparsematrix()
{
   int i,j,r,c,ele,pos=0;
   printf("Enter rows and cols:\n");
   scanf("%d%d", &r,&c);
   for (i = 0; i < r; i++)
{
      for (j = 0; j < c; j++)
{
                  scanf("%d", &ele);
                  if (ele != 0)
{
                        pos++;
                        s[pos].row = i;
                        s[pos].col = j;
                        s[pos].val = ele;
            }
         }
     }
   s[0].row = r;
   s[0].col = c;
```

```
   s[0].val = pos;
}
void triplet()
{
          int i;
          printf("\nTriplet representation:\n");
          printf("Row  Col  Value\n");
          for (i = 0; i <= s[0].val; i++)
{
       printf("%d    %d    %d\n", s[i].row, s[i].col, s[i].val);
          }
}
void search()
{
          int found=0,key,i;
          printf("Enter key:\n");
          scanf("%d", &key);
          for (i = 1; i <= s[0].val; i++)
{
       if (s[i].val == key)
  {
          printf("%d    %d    \n", s[i].row, s[i].col);
          found=1;
          break;
        }
   }
   if(found==0)
          printf("\n element not  found:");
```

```
}
void transpose()
{
   int i,j;
   struct sparse trans[10];
   trans[0].row = s[0].col;
   trans[0].col = s[0].row;
   trans[0].val = s[0].val;
   int k = 1;
   for (i = 0; i < s[0].col; i++)
   {
      for (j = 1; j <= s[0].val; j++)
       {
         if (s[j].col == i)
          {
            trans[k].row = s[j].col;
            trans[k].col = s[j].row;
            trans[k].val = s[j].val;
            k++;
          }
       }
    }
   for (i = 0; i <= s[0].val; i++)
  {
      s[i] = trans[i];
   }
   triplet();
}
```

```
int main()
{
        readsparsematrix();
        triplet();
        search();
        transpose();
        return 0;
}
```

Output:

```
Enter rows and cols:
4 5
0 0 3 0 4
0 0 5 7 0
0 0 0 0 0
0 2 6 0 0

Triplet representation:
Row   Col   Value
4     5     6
0     2     3
0     4     4
1     2     5
1     3     7
3     1     2
3     2     6
Enter key:
7
1     3

Triplet representation:
Row   Col   Value
5     4     6
1     3     2
2     0     3
2     1     5
2     3     6
3     1     7
4     0     4

--------------------------------
Process exited after 87.55 seconds with return value 0
Press any key to continue . . .
```

Ex : 10

Title: Design and develop a Program in C that uses Hash function H: K ->L as H(K)=K mod m and implement hashing technique to map a given key K to the address space L. Resolvethe collision (if any).

Problem Description: Given a set K of Keys (4-digit) which uniquely determines the records in file F. Assume that file F ismaintained in memory by a Hash Table (HT) of m memory locations with L as the set of memory addresses (2-digit) of locations in HT. Let the keys in K and addresses in L are Integers.

Method: Ensure that the program generates the 4-digit key randomly and generates the L using

hash function, demonstratesif there is a collision and its resolution by using linear probing.

Theory Reference: Module 5

Explanation:

1. **Linear Probing**: Collisions are resolved by checking the next available index (index1 = (index1 + 1) % m;), which continues until an empty slot (-1) is found.
2. **Memory Allocation**: The hash table (a) is dynamically allocated using malloc.
3. **Handling Table Full Condition**: If the hash table is full, it stops inserting further keys and reports the issue.

Algorithm:

Step 1: Initialize the Hash Table

1. **Create an array** `a` of size `m` (in this case, `m = 20`), and initialize all elements to `-1` to represent empty slots.
2. Set `count = 0` to keep track of the number of elements inserted into the hash table.

Step 2: Input the Number of Keys and Validate

1. Ask the user for the number of keys to insert into the hash table.
2. **Validate the input**:
    - If the number of keys `n` is greater than `m`, print an error message and terminate the program (since the hash table cannot accommodate more keys than its size).

Step 3: Input the Keys

1. Ask the user to input `n` keys (each key is a 4-digit integer).
2. Store the keys in an array `key[20]`.

Step 4: Insert Keys into the Hash Table Using Linear Probing

For each key in the array `key[]`:

1. **Compute the index** where the key should be inserted:

- Use the hash function: `index1 = key % m` (this gives an index in the range `0` to `m-1`).

2. **Linear Probing** to resolve collisions:
   - Check if the slot at index `index1` is occupied (`a[index1] != -1`):
     - If occupied, move to the next slot: `index1 = (index1 + 1) % m`.
     - Repeat this process until an empty slot is found (i.e., `a[index1] == -1`).
3. **Insert the key**:
   - Once an empty slot is found, insert the key at that index: `a[index1] = key`.
   - Increment the `count` to indicate that a key has been successfully inserted.
4. **Check if the hash table is full**:
   - If `count == m`, print a message indicating the table is full and stop inserting further keys.

Step 5: Display the Hash Table

1. Traverse the array `a[]` and print the keys stored in the hash table. For each index:
   - If the slot is empty (`a[i] == -1`), print "Empty".
   - Otherwise, print the key stored at that index.

Program

```
#include<stdio.h>

#include<stdlib.h>

#define m 20

int key[20],n;

int *a,index1;

int count = 0;

void linearprobing(int key)

{

   index1 = key % m;

   while (a[index1] != -1)
```

```
    {
        index1 = (index1 + 1) % m;// collision resolved using linear probing
    }
    a[index1] = key;
    count++;
}
void display()
{
    int i;
    if (count == 0)
    {
        printf("\nHash Table is empty");
        return;
    }
    printf("\nHash Table contents are:\n ");
    for (i = 0; i < m; i++)
        printf("\n T[%d] --> %d ", i, a[i]);
}
void main()
{
```

```
    int i;
    printf("\nEnter the number of four digit key values: ");
    scanf("%d",&n);
    a = (int *) malloc(m * sizeof(int));
    for (i = 0; i < m; i++)
        a[i] = -1;
    printf("\nEnter the four digit key values (K):\n ");
    for (i = 0; i < n; i++)
        scanf("%4d", &key[i]);
    for (i = 0; i < n; i++)
    {
        if (count == m)
        {
            printf("\n-----Hash table is full. Cannot insert the record %d key-----", i + 1);
            break;
        }
        linearprobing(key[i]);
    }
    display();
}
```

Output

```
Enter the number of four digit key values: 10

Enter the four digit key values (K):
 4020
  4560
  9908
  6785
  0423
  7890
  6547
  3342
  9043
  6754

Hash Table contents are:

 T[0] --> 4020
 T[1] --> 4560
 T[2] --> 3342
 T[3] --> 423
 T[4] --> 9043
 T[5] --> 6785
 T[6] --> -1
 T[7] --> 6547
 T[8] --> 9908
 T[9] --> -1
 T[10] --> 7890
 T[11] --> -1
 T[12] --> -1
 T[13] --> -1
 T[14] --> 6754
 T[15] --> -1
 T[16] --> -1
 T[17] --> -1
 T[18] --> -1
 T[19] --> -1
--------------------------------
Process exited after 16.61 seconds with return value 15
Press any key to continue . . .
```