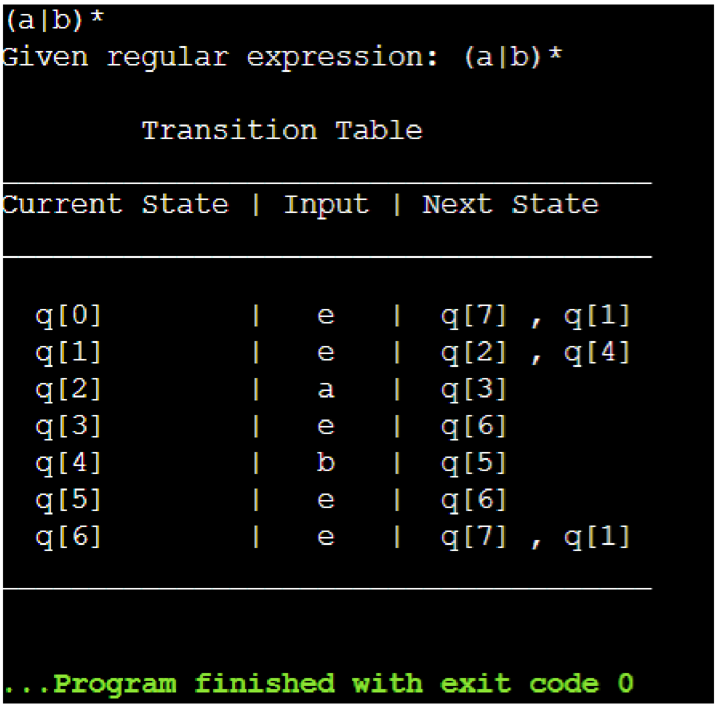
Practical – 5

Objective: WAP to convert regular expression to equivalent NFA**.**

5.A- Source Code:-

```
#include<stdio.h>
#include<string.h>
int main()
{
        char reg[20]; int q[20][3],i=0,j=1,len,a,b;
        for(a=0;a<20;a++) for(b=0;b<3;b++) q[a][b]=0;
        scanf("%s",reg);
        printf("Given regular expression: %s\n",reg);
        len=strlen(reg);
        while(i<len)
        {
                if(reg[i]=='a'&&reg[i+1]!='|'&&reg[i+1]!='*') { q[j][0]=j+1; j++; }
                if(reg[i]=='b'&&reg[i+1]!='|'&&reg[i+1]!='*') {     q[j][1]=j+1; j++;       }
                if(reg[i]=='e'&&reg[i+1]!='|'&&reg[i+1]!='*') {     q[j][2]=j+1; j++;       }
                if(reg[i]=='a'&&reg[i+1]=='|'&&reg[i+2]=='b')
                {
                  q[j][2]=((j+1)*10)+(j+3); j++;
                  q[j][0]=j+1; j++;
                        q[j][2]=j+3; j++;
                        q[j][1]=j+1; j++;
                        q[j][2]=j+1; j++;
                        i=i+2;
                }
                if(reg[i]=='b'&&reg[i+1]=='|'&&reg[i+2]=='a')
                {
                        q[j][2]=((j+1)*10)+(j+3); j++;
                        q[j][1]=j+1; j++;
                        q[j][2]=j+3; j++;
                        q[j][0]=j+1; j++;
                        q[j][2]=j+1; j++;
                        i=i+2;
                }
                if(reg[i]=='a'&&reg[i+1]=='*')
                {
                        q[j][2]=((j+1)*10)+(j+3); j++;
                        q[j][0]=j+1; j++;
                        q[j][2]=((j+1)*10)+(j-1); j++;
                }
                if(reg[i]=='b'&&reg[i+1]=='*')
                {
                        q[j][2]=((j+1)*10)+(j+3); j++;
                        q[j][1]=j+1; j++;
                        q[j][2]=((j+1)*10)+(j-1); j++;
                }
                if(reg[i]==')'&&reg[i+1]=='*')
                {
                        q[0][2]=((j+1)*10)+1;
                        q[j][2]=((j+1)*10)+1;
                        j++;
                }
                i++;
        }
        printf("\n\tTransition Table \n");
        printf("_____________________________________________\n");
        printf("Current State |\tInput |\tNext State");
        printf("\n_____________________________________________\n");
        for(i=0;i<=j;i++)
        {
                if(q[i][0]!=0) printf("\n  q[%d]\t      |  a   |  q[%d]",i,q[i][0]);
                if(q[i][1]!=0) printf("\n  q[%d]\t      |  b   |  q[%d]",i,q[i][1]);
                if(q[i][2]!=0)
                {
                        if(q[i][2]<10) printf("\n  q[%d]\t      |  e   |  q[%d]",i,q[i][2]);
                        else printf("\n  q[%d]\t      |  e   |  q[%d] ,
q[%d]",i,q[i][2]/10,q[i][2]%10);
                }
        }
        printf("\n_____________________________________________\n");
        return 0;
}
```

Output:



```
(a|b)*
Given regular expression: (a|b)*

        Transition Table
_____________________________________________
Current State |  Input |  Next State
_____________________________________________

  q[0]          |   e    |  q[7] , q[1]
  q[1]          |   e    |  q[2] , q[4]
  q[2]          |   a    |  q[3]
  q[3]          |   e    |  q[6]
  q[4]          |   b    |  q[5]
  q[5]          |   e    |  q[6]
  q[6]          |   e    |  q[7] , q[1]
_____________________________________________


...Program finished with exit code 0
```

Practical – 6

Objective: WAP to convert NFA to equivalent DFA.

6.A: Source code:-

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#define MAX_LEN 100

char NFA_FILE[MAX_LEN];
char buffer[MAX_LEN];
int zz = 0;

struct DFA {
char *states;
int count;
} dfa;

int last_index = 0;
FILE *fp;
int symbols;

void reset(int ar[], int size) {
int i;

for (i = 0; i < size; i++) {
        ar[i] = 0;
}
}

void check(int ar[], char S[]) {
int i, j;

int len = strlen(S);
for (i = 0; i < len; i++) {

        j = ((int)(S[i]) - 65);
        ar[j]++;
}
}

void state(int ar[], int size, char S[]) {
int j, k = 0;
for (j = 0; j < size; j++) {
        if (ar[j] != 0)
        S[k++] = (char)(65 + j);
}
S[k] = '\0';
}
int closure(int ar[], int size) {
int i;
for (i = 0; i < size; i++) {
        if (ar[i] == 1)
        return i;
}
return (100);
}
int indexing(struct DFA *dfa) {
int i;

for (i = 0; i < last_index; i++) {
        if (dfa[i].count == 0)
        return 1;
}
return -1;
}
void Display_closure(int states, int closure_ar[],
                                        char *closure_table[],
                                        char *NFA_TABLE[][symbols + 1],
                                        char *DFA_TABLE[][symbols]) {
int i;
for (i = 0; i < states; i++) {
        reset(closure_ar, states);
        closure_ar[i] = 2;
        if (strcmp(&NFA_TABLE[i][symbols], "-") != 0) {
        strcpy(buffer, &NFA_TABLE[i][symbols]);
        check(closure_ar, buffer);
        int z = closure(closure_ar, states);

        while (z != 100)
        {
                if (strcmp(&NFA_TABLE[z][symbols], "-") != 0) {
                strcpy(buffer, &NFA_TABLE[z][symbols]);

                check(closure_ar, buffer);
                }
                closure_ar[z]++;
                z = closure(closure_ar, states);
        }
        }
        printf("\n e-Closure (%c) :\t", (char)(65 + i));

        bzero((void *)buffer, MAX_LEN);
        state(closure_ar, states, buffer);
        strcpy(&closure_table[i], buffer);
        printf("%s\n", &closure_table[i]);
}
}
```

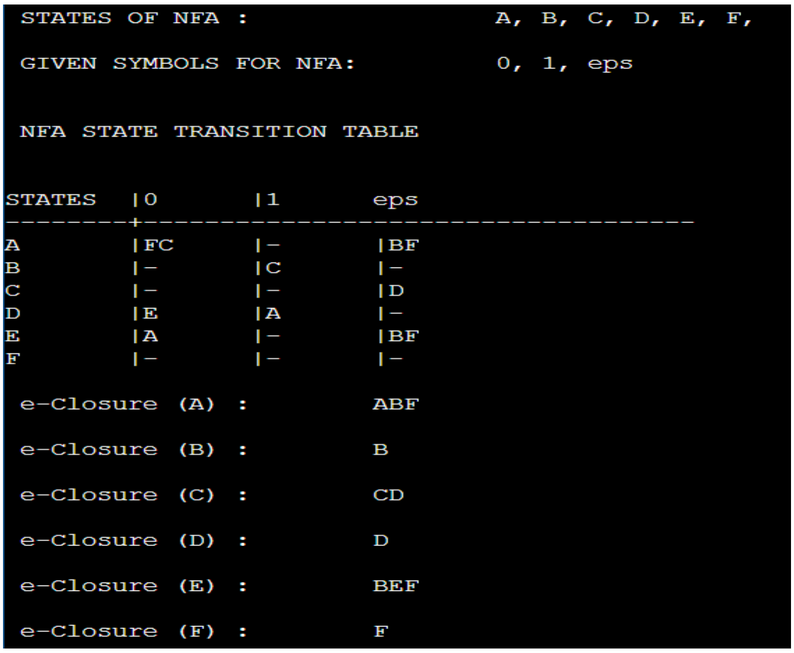
```
int new_states(struct DFA *dfa, char S[]) {

int i;

for (i = 0; i < last_index; i++) {
        if (strcmp(&dfa[i].states, S) == 0)
        return 0;
}

strcpy(&dfa[last_index++].states, S);

dfa[last_index - 1].count = 0;
return 1;
}

void trans(char S[], int M, char *clsr_t[], int st,
                        char *NFT[][symbols + 1], char TB[]) {
int len = strlen(S);
int i, j, k, g;
int arr[st];
int sz;
reset(arr, st);
char temp[MAX_LEN], temp2[MAX_LEN];
char *buff;

for (i = 0; i < len; i++) {

        j = ((int)(S[i] - 65));
        strcpy(temp, &NFT[j][M]);

        if (strcmp(temp, "-") != 0) {
        sz = strlen(temp);
        g = 0;

        while (g < sz) {
                k = ((int)(temp[g] - 65));
                strcpy(temp2, &clsr_t[k]);
                check(arr, temp2);
                g++;
        }
        }
}

bzero((void *)temp, MAX_LEN);
state(arr, st, temp);
if (temp[0] != '\0') {
        strcpy(TB, temp);
} else
        strcpy(TB, "-");
}
```

```
/* Display DFA transition state table*/
void Display_DFA(int last_index, struct DFA *dfa_states,
                char *DFA_TABLE[][symbols]) {
int i, j;
printf("\n\n****************************************************************\n\n");
printf("\t\t DFA TRANSITION STATE TABLE \t\t \n\n");
printf("\n STATES OF DFA :\t\t");

for (i = 1; i < last_index; i++)
    printf("%s, ", &dfa_states[i].states);
printf("\n");
printf("\n GIVEN SYMBOLS FOR DFA: \t");

for (i = 0; i < symbols; i++)
    printf("%d, ", i);
printf("\n\n");
printf("STATES\t");

for (i = 0; i < symbols; i++)
    printf("|%d\t", i);
printf("\n");

// display the DFA transition state table
printf("--------+-----------------------\n");
for (i = 0; i < zz; i++) {
    printf("%s\t", &dfa_states[i + 1].states);
    for (j = 0; j < symbols; j++) {
    printf("|%s \t", &DFA_TABLE[i][j]);
    }
    printf("\n");
}
}

// Driver Code
int main() {
int i, j, states;
char T_buf[MAX_LEN];

struct DFA *dfa_states = malloc(MAX_LEN * (sizeof(dfa)));
states = 6, symbols = 2;

printf("\n STATES OF NFA :\t\t");
for (i = 0; i < states; i++)

    printf("%c, ", (char)(65 + i));
printf("\n");
printf("\n GIVEN SYMBOLS FOR NFA: \t");

for (i = 0; i < symbols; i++)
```

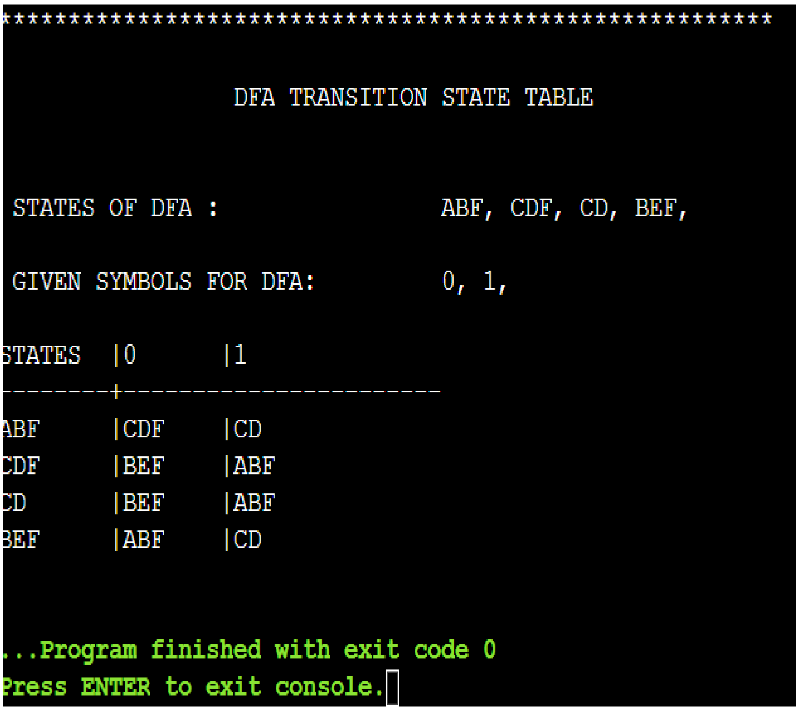
```
        printf("%d, ", i);
printf("eps");
printf("\n\n");
char *NFA_TABLE[states][symbols + 1];

char *DFA_TABLE[MAX_LEN][symbols];
strcpy(&NFA_TABLE[0][0], "FC");
strcpy(&NFA_TABLE[0][1], "-");
strcpy(&NFA_TABLE[0][2], "BF");
strcpy(&NFA_TABLE[1][0], "-");
strcpy(&NFA_TABLE[1][1], "C");
strcpy(&NFA_TABLE[1][2], "-");
strcpy(&NFA_TABLE[2][0], "-");
strcpy(&NFA_TABLE[2][1], "-");
strcpy(&NFA_TABLE[2][2], "D");
strcpy(&NFA_TABLE[3][0], "E");
strcpy(&NFA_TABLE[3][1], "A");
strcpy(&NFA_TABLE[3][2], "-");
strcpy(&NFA_TABLE[4][0], "A");
strcpy(&NFA_TABLE[4][1], "-");
strcpy(&NFA_TABLE[4][2], "BF");
strcpy(&NFA_TABLE[5][0], "-");
strcpy(&NFA_TABLE[5][1], "-");
strcpy(&NFA_TABLE[5][2], "-");
printf("\n NFA STATE TRANSITION TABLE \n\n\n");
printf("STATES\t");

for (i = 0; i < symbols; i++)
        printf("|%d\t", i);
printf("eps\n");

// Displaying the matrix of NFA transition table
printf("--------+------------------------------------\n");
for (i = 0; i < states; i++) {
        printf("%c\t", (char)(65 + i));

        for (j = 0; j <= symbols; j++) {
        printf("|%s \t", &NFA_TABLE[i][j]);
        }
        printf("\n");
}
int closure_ar[states];
char *closure_table[states];

Display_closure(states, closure_ar, closure_table, NFA_TABLE, DFA_TABLE);
strcpy(&dfa_states[last_index++].states, "-");

dfa_states[last_index - 1].count = 1;
bzero((void *)buffer, MAX_LEN);
```

```
strcpy(buffer, &closure_table[0]);
strcpy(&dfa_states[last_index++].states, buffer);

int Sm = 1, ind = 1;
int start_index = 1;

while (ind != -1) {
        dfa_states[start_index].count = 1;
        Sm = 0;
        for (i = 0; i < symbols; i++) {

        trans(buffer, i, closure_table, states, NFA_TABLE, T_buf);

        strcpy(&DFA_TABLE[zz][i], T_buf);

        Sm = Sm + new_states(dfa_states, T_buf);
        }
        ind = indexing(dfa_states);
        if (ind != -1)
        strcpy(buffer, &dfa_states[++start_index].states);
        zz++;
}

Display_DFA(last_index, dfa_states, DFA_TABLE);

return 0;
}
```

Output:



```
 STATES OF NFA :                A, B, C, D, E, F,

 GIVEN SYMBOLS FOR NFA:         0, 1, eps


 NFA STATE TRANSITION TABLE


STATES   |0       |1       eps
--------+------------------------------------
A        |FC      |-       |BF
B        |-       |C       |-
C        |-       |-       |D
D        |E       |A       |-
E        |A       |-       |BF
F        |-       |-       |-

 e-Closure (A) :          ABF

 e-Closure (B) :          B

 e-Closure (C) :          CD

 e-Closure (D) :          D

 e-Closure (E) :          BEF

 e-Closure (F) :          F
```



```
*******************************************************


                 DFA TRANSITION STATE TABLE



 STATES OF DFA :                ABF, CDF, CD, BEF,


 GIVEN SYMBOLS FOR DFA:         0, 1,


STATES   |0       |1
--------+-----------------------
ABF      |CDF     |CD
CDF      |BEF     |ABF
CD       |BEF     |ABF
BEF      |ABF     |CD



...Program finished with exit code 0
Press ENTER to exit console.
```

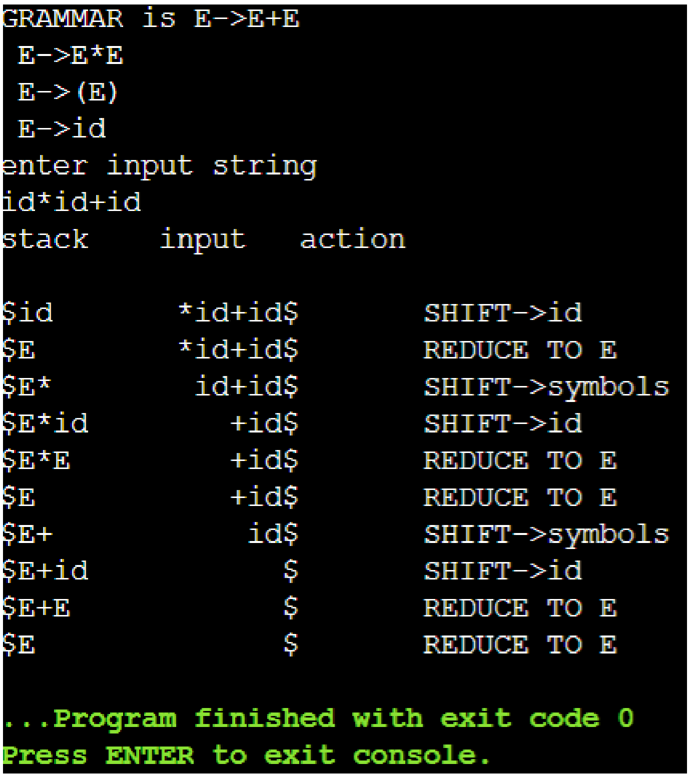
Practical – 7

Objective: WAP to implement shift reduce parser.

7.A- Source Code:-

```
#include<stdio.h>
#include<string.h>
int k=0,z=0,i=0,j=0,c=0;
char a[16],ac[20],stk[15],act[10];
void check();
int main()
  {

     puts("GRAMMAR is E->E+E \n E->E*E \n E->(E) \n E->id");
     puts("enter input string ");
     gets(a);
     c=strlen(a);
     strcpy(act,"SHIFT->");
     puts("stack \t input \t action");
     for(k=0,i=0; j<c; k++,i++,j++){
       if(a[j]=='i' && a[j+1]=='d'){
            stk[i]=a[j];
            stk[i+1]=a[j+1];
            stk[i+2]='\0';
            a[j]=' ';
            a[j+1]=' ';
            printf("\n$%s\t%s$\t%sid",stk,a,act);
            check();
          }
       else{
            stk[i]=a[j];
            stk[i+1]='\0';
            a[j]=' ';
            printf("\n$%s\t%s$\t%ssymbols",stk,a,act);
            check();
          }
      }

  }
void check(){
    strcpy(ac,"REDUCE TO E");
    for(z=0; z<c; z++)
      if(stk[z]=='i' && stk[z+1]=='d'){
          stk[z]='E';
          stk[z+1]='\0';
          printf("\n$%s\t%s$\t%s",stk,a,ac);
          j++;
      }
    for(z=0; z<c; z++)
     if(stk[z]=='E' && stk[z+1]=='+' && stk[z+2]=='E')
      {
       stk[z]='E';
       stk[z+1]='\0';
       stk[z+2]='\0';
       printf("\n$%s\t%s$\t%s",stk,a,ac);
       i=i-2;
      }
    for(z=0; z<c; z++){
     if(stk[z]=='E' && stk[z+1]=='*' && stk[z+2]=='E') {
       stk[z]='E';
       stk[z+1]='\0';
       stk[z+1]='\0';
       printf("\n$%s\t%s$\t%s",stk,a,ac);
       i=i-2;
      }
    for(z=0; z<c; z++){
     if(stk[z]=='(' && stk[z+1]=='E' && stk[z+2]==')') {
       stk[z]='E';
       stk[z+1]='\0';
       stk[z+1]='\0';
       printf("\n$%s\t%s$\t%s",stk,a,ac);
       i=i-2;
      }
   }
```

Output:



```
GRAMMAR is E->E+E
 E->E*E
 E->(E)
 E->id
enter input string
id*id+id
stack    input    action

$id       *id+id$       SHIFT->id
$E        *id+id$       REDUCE TO E
$E*        id+id$       SHIFT->symbols
$E*id        +id$       SHIFT->id
$E*E         +id$       REDUCE TO E
$E           +id$       REDUCE TO E
$E+           id$       SHIFT->symbols
$E+id           $       SHIFT->id
$E+E            $       REDUCE TO E
$E              $       REDUCE TO E

...Program finished with exit code 0
Press ENTER to exit console.
```

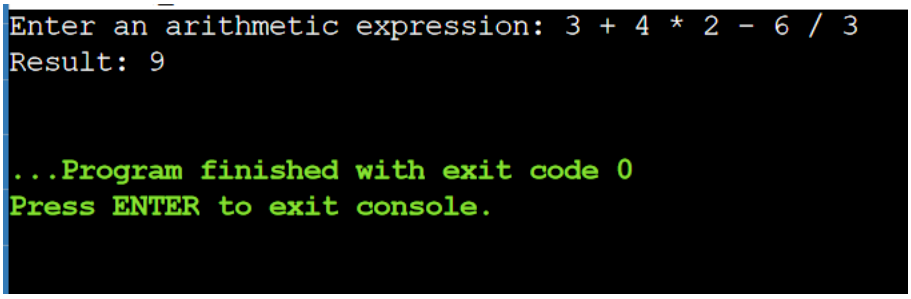
Practical – 8

Objective: WAP to implement Operator Precedence parser.

8.A- Source Code:-

```
#include <iostream>
#include <stack>
#include <string>

using namespace std;

// Function to check if a character is an operator
bool isOperator(char c) {
    return (c == '+' || c == '-' || c == '*' || c == '/');
}

// Function to get the precedence of an operator
int getPrecedence(char op) {
    if (op == '+' || op == '-')
        return 1;
    else if (op == '*' || op == '/')
        return 2;
    return 0;
}

// Function to perform an operation
int performOperation(int operand1, int operand2, char op) {
    switch (op) {
        case '+':
            return operand1 + operand2;
        case '-':
            return operand1 - operand2;
        case '*':
            return operand1 * operand2;
        case '/':
            if (operand2 != 0)
                return operand1 / operand2;
            else {
                cout << "Error: Division by zero" << endl;
                exit(1);
            }
    }
    return 0;
}

// Function to evaluate the expression using operator precedence parsing
int evaluateExpression(const string& expression) {
    stack<int> operandStack;
    stack<char> operatorStack;

    for (char c : expression) {
        if (isspace(c)) {
            continue;
        } else if (isdigit(c)) {
            int operand = c - '0';
            operandStack.push(operand);
        } else if (isOperator(c)) {
            while (!operatorStack.empty() && getPrecedence(operatorStack.top()) >=
getPrecedence(c)) {
                int operand2 = operandStack.top();
                operandStack.pop();

                int operand1 = operandStack.top();
                operandStack.pop();

                char op = operatorStack.top();
                operatorStack.pop();

                int result = performOperation(operand1, operand2, op);
                operandStack.push(result);
            }

            operatorStack.push(c);
        } else {
            cout << "Error: Invalid character '" << c << "'" << endl;
            exit(1);
        }
    }

    while (!operatorStack.empty()) {
        int operand2 = operandStack.top();
        operandStack.pop();

        int operand1 = operandStack.top();
        operandStack.pop();
        char op = operatorStack.top();
        operatorStack.pop();

        int result = performOperation(operand1, operand2, op);
        operandStack.push(result);
    }

    return operandStack.top();
}

int main() {
    string expression;
    cout << "Enter an arithmetic expression: ";
    getline(cin, expression);

    int result = evaluateExpression(expression);
    cout << "Result: " << result << endl;

    return 0;
}
```

Output:



```
Enter an arithmetic expression: 3 + 4 * 2 - 6 / 3
Result: 9


...Program finished with exit code 0
Press ENTER to exit console.
```

Practical – 9

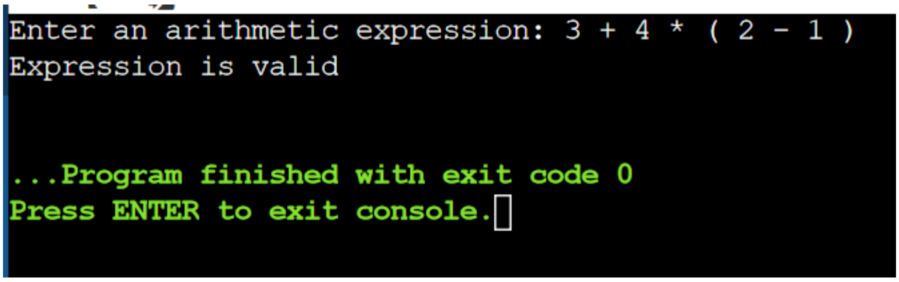
Objective: WAP to implement Recursive Descent parser.

9.A- Source Code:-

```
#include <iostream>
#include <cctype>
#include <cstdlib>
#include <algorithm> // Include the <algorithm> header for remove_if

using namespace std;

string input;
size_t position = 0;

void error() {
   cout << "Error: Invalid expression" << endl;
   exit(1);
}

char getNextToken() {
   return input[position++];
}

void factor();
void term();
void expr();

void factor() {
   char token = getNextToken();
   if (isdigit(token)) {
      // Valid factor
   } else if (token == '(') {
      expr();
      token = getNextToken();
      if (token != ')')
         error();
   } else {
      error();
   }
}
```

```
void term() {
    factor();
    char token = getNextToken();
    while (token == '*' || token == '/') {
        factor();
        token = getNextToken();
    }
    position--; // Move the position back to the last valid token
}

void expr() {
    term();
    char token = getNextToken();
    while (token == '+' || token == '-') {
        term();
        token = getNextToken();
    }
    position--; // Move the position back to the last valid token
}

int main() {
    cout << "Enter an arithmetic expression: ";
    getline(cin, input);
    input.erase(remove_if(input.begin(), input.end(), [](char c) { return isspace(c); }),
input.end());
    input += '$'; // Add end marker
    expr();
    if (input[position] == '$') {
        cout << "Expression is valid" << endl;
    } else {
        cout << "Expression is invalid" << endl;
    }
    return 0;
}
```

Output:



```
Enter an arithmetic expression: 3 + 4 * ( 2 - 1 )
Expression is valid


...Program finished with exit code 0
Press ENTER to exit console.
```

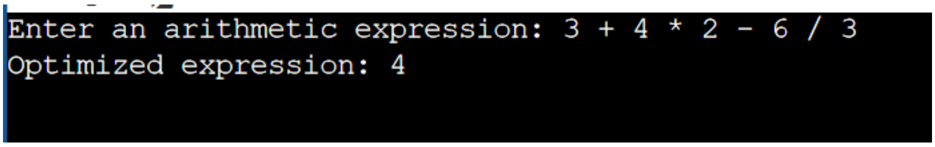
Practical – 10

Objective: WAP to implement Code Optimization Techniques.

10.A- Source Code:-

```
#include <iostream>
#include <string>
#include <cctype>

using namespace std;

int evaluateExpression(int operand1, int operand2, char op) {
    switch (op) {
        case '+':
            return operand1 + operand2;
        case '-':
            return operand1 - operand2;
        case '*':
            return operand1 * operand2;
        case '/':
            if (operand2 != 0)
                return operand1 / operand2;
            else {
                cout << "Error: Division by zero" << endl;
                exit(1);
            }
    }
    return 0;
}

string optimizeExpression(const string& expression) {
    int operand1 = 0;
    int operand2 = 0;
    char op = '+';
    int result = 0;

    for (char c : expression) {
        if (isspace(c)) {
            continue;
        } else if (isdigit(c)) {
            operand2 = operand2 * 10 + (c - '0');
        } else {
            result = evaluateExpression(result, operand2, op);
            op = c;
            operand2 = 0;
        }
    }

    result = evaluateExpression(result, operand2, op);
    return to_string(result);
}

int main() {
    string expression;
    cout << "Enter an arithmetic expression: ";
    getline(cin, expression);

    string optimizedExpression = optimizeExpression(expression);
    cout << "Optimized expression: " << optimizedExpression << endl;

    return 0;
}
```

Output:



```
Enter an arithmetic expression: 3 + 4 * 2 - 6 / 3
Optimized expression: 4
```

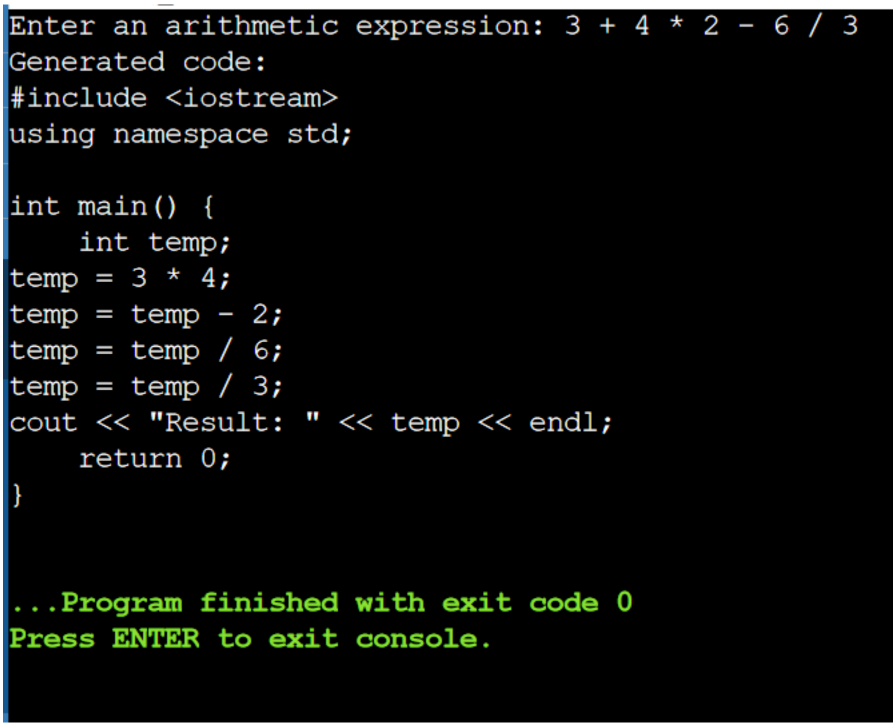
Practical – 11

Objective: WAP to implement Code Generator.

11.A- Source Code:-

```
#include <iostream>
#include <string>
#include <stack>
#include <cctype>

using namespace std;

string generateCode(const string& expression) {
    string code;
    stack<string> operandStack;
    stack<char> operatorStack;

    for (size_t i = 0; i < expression.length(); i++) {
        char c = expression[i];

        if (isspace(c)) {
            continue;
        } else if (isdigit(c)) {
            size_t j = i;
            string number;
            while (j < expression.length() && isdigit(expression[j])) {
                number += expression[j];
                j++;
            }
            operandStack.push(number);
            i = j - 1;
        } else if (c == '+' || c == '-' || c == '*' || c == '/') {
            while (!operatorStack.empty() && operatorStack.top() != '(') {
                string operand2 = operandStack.top();
                operandStack.pop();
                string operand1 = operandStack.top();
                operandStack.pop();

                code += "temp = " + operand1 + " " + c + " " + operand2 + ";\n";
                operandStack.push("temp");
                operatorStack.pop();
            }
            operatorStack.push(c);
        } else if (c == '(') {
            operatorStack.push(c);
        } else if (c == ')') {
            while (!operatorStack.empty() && operatorStack.top() != '(') {
                string operand2 = operandStack.top();
                operandStack.pop();
                string operand1 = operandStack.top();
                operandStack.pop();

                code += "temp = " + operand1 + " " + operatorStack.top() + " " + operand2 + ";\n";
                operandStack.push("temp");
                operatorStack.pop();
            }

            if (!operatorStack.empty())
                operatorStack.pop(); // Remove '('
        } else {
            cout << "Error: Invalid character '" << c << "'" << endl;
            exit(1);
        }
    }

    while (!operatorStack.empty()) {
        string operand2 = operandStack.top();
        operandStack.pop();
        string operand1 = operandStack.top();
        operandStack.pop();

        code += "temp = " + operand1 + " " + operatorStack.top() + " " + operand2 + ";\n";
        operandStack.push("temp");
        operatorStack.pop();
    }

    code += "cout << \"Result: \" << temp << endl;\n";
    return code;
}

int main() {
    string expression;
    cout << "Enter an arithmetic expression: ";
    getline(cin, expression);

    string code = generateCode(expression);

    cout << "Generated code:\n";
    cout << "#include <iostream>\n";
    cout << "using namespace std;\n\n";
    cout << "int main() {\n";
    cout << "    int temp;\n";
    cout << code;
    cout << "    return 0;\n";
    cout << "}\n";

    return 0;
}
```

Output:



```
Enter an arithmetic expression: 3 + 4 * 2 - 6 / 3
Generated code:
#include <iostream>
using namespace std;

int main() {
    int temp;
temp = 3 * 4;
temp = temp - 2;
temp = temp / 6;
temp = temp / 3;
cout << "Result: " << temp << endl;
    return 0;
}


...Program finished with exit code 0
Press ENTER to exit console.
```

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Computer Science and Engineering Department
Compiler Design Lab (PCS-601)

Index/List Of Experiments

Sr. No.	Experiment	Date	Signature