ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY

(Approved by AICTE New Delhi, Affiliated to Anna University, Chennai)

(An ISO 9001:2015 Certified Institution)

ANGUCHETTYPLAYAM, PANRUTI – 607 106.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

LAB MANUAL

CS6612 – COMPILER LABORATORY

Regulation 2013

Year / Semester : VI / III

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PREPARED BY

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SYLLABUS

CS6612 COMPILER LABORATORY L T P C 0 0 3 2

OBJECTIVES:

The student should be made to:

- ✓ Be exposed to compiler writing tools.
- ✓ Learn to implement the different Phases of compiler
- ✓ Be familiar with control flow and data flow analysis
- ✓ Learn simple optimization techniques

LIST OF EXPERIMENTS:

1. Implementation of Symbol Table
2. Develop a lexical analyzer to recognize a few patterns in C.
(Ex. identifiers, constants, comments, operators etc.)
3. Implementation of Lexical Analyzer using Lex Tool
4. Generate YACC specification for a few syntactic categories.

a) Program to recognize a valid arithmetic expression that usesoperator +, - , * and /.

b) Program to recognize a valid variable which starts with a letter followed by any number of letters or digits.

c)Implementation of Calculator using LEX and YACC

5. Convert the BNF rules into Yacc form and write code to generate Abstract Syntax Tree.
6. Implement type checking
7. Implement control flow analysis and Data flow Analysis
8. Implement any one storage allocation strategies(Heap,Stack,Static)
9. Construction of DAG
10. Implement the back end of the compiler which takes the three address code and produces the 8086 assembly language instructions that can be assembled and run using a 8086 assembler. The target assembly instructions can be simple move, add, sub, jump. Also simple addressing modes are used.
11. Implementation of Simple Code Optimization Techniques (Constant Folding., etc.)

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the student should be able to

- ✓ Implement the different Phases of compiler using tools
- ✓ Analyze the control flow and data flow of a typical program
- ✓ Optimize a given program
- ✓ Generate an assembly language program equivalent to a source language program

LIST OF EQUIPMENT FOR A BATCH OF 30 STUDENTS:

Standalone desktops with C / C++ compiler and Compiler writing tools 30 Nos.

(or)

Server with C / C++ compiler and Compiler writing tools supporting 30 terminals or more. LEX and YACC

TABLE OF CONTENTS

Ex.No : 1

DATE:

IMPLEMENTATION OF SYMBOL TABLE

AIM:

To write a C program to implement Symbol Table.

ALGORITHM:

1. Start the program for performing insert, display, delete, search and modify option in symbol table
2. Define the structure of the Symbol Table
3. Enter the choice for performing the operations in the symbol Table
4. If the entered choice is 1, search the symbol table for the symbol to be inserted. If the symbol is already present, it displays “Duplicate Symbol”. Else, insert the symbol and the corresponding address in the symbol table.
5. If the entered choice is 2, the symbols present in the symbol table are displayed.
6. If the entered choice is 3, the symbol to be deleted is searched in the symbol table. If it is not found in the symbol table it displays “Label Not found”. Else, the symbol is deleted.
7. If the entered choice is 5, the symbol to be modified is searched in the symbol table. The label or address or both can be modified.

PROGRAM:

```
#include<stdio.h>
#include<conio.h>
#include<stdlib.h>
#include<string.h>
struct table
{
        char var[10];
        int value;
};
struct table tbl[20];
int i,j,n;
void create();
void modify();
int search(char variable[],int n);
void insert();
void display();
void main()
{
        int ch,result=0;
        char v[10];
        clrscr();
        do
        {
                printf("Enter your choice\n1.Create\n2.Insert\n3.Modify\n4.Search\n5.Display\n6.Exit:");
                scanf("%d",&ch);
                switch(ch)
                {
                        case 1:
                                create();
                                break;
                        case 2:
                                insert();
                                break;
                        case 3:
                                modify();
                                break;
                        case 4:
                                printf("Enter the variable to be searched for:\n");
                                scanf("%s",&v);
                                result=search(v,n);
                                if(result==0)
                                printf("The variable does not belong to the table\n");
                                else
```

```
                        printf("The location of the variable is %d\nThe value of %s is
                    %d\n",result,tbl[result].var,tbl[result].value);
                        break;
                    case 5:
                        display();
                        break;
                    case 6:
                        exit(1);
                    }
                }
        while(ch!=6);
        getch();
}
void create()
{
        printf("Enter the no. of entries:");
        scanf("%d",&n);
        printf("Enter the variable and the value:\n");
        for(i=1;i<=n;i++)
        {
                scanf("%s%d",tbl[i].var,&tbl[i].value);
                check:
                if(tbl[i].var[0]>='0'&&tbl[i].var[0]<='9')
                {
                        printf("The variable should start with an alphabet\nEnter correct variable name:\n");
                        scanf("%s%d",tbl[i].var,&tbl[i].value);
                        goto check;
                }
                check1:
                for(j=1;j<i;j++)
                {
                        if(strcmp(tbl[i].var,tbl[j].var)==0)
                        {
                                printf("The variable already exists.Enter another variable\n");
                                scanf("%s%d",tbl[i].var,&tbl[i].value);
                                goto check1;
                        }
                }
        }
        printf("The table after creation is:\n");
        display();
}
void insert()
{
        if(i>=20)
                printf("Cannot insert.Table is full\n");
        else
        {
```

```
                n++;
                printf("Enter the value and variable\n");
                scanf("%s%d",tbl[n].var,&tbl[n].value);
                check:
                if(tbl[i].var[0]>='0'&&tbl[i].var[0]<='9')
                {
                        printf("The variable should start with an alphabet\nEnter correct variable name:\n");
                        scanf("%s%d",tbl[i].var,&tbl[i].value);
                        goto check;
                }
                check1:
                for(j=1;j<n;j++)
                {
                        if(strcmp(tbl[j].var,tbl[i].var)==0)
                        {
                                printf("The variable already exist.Enter another variable\n");
                                scanf("%s%d",tbl[i].var,&tbl[i].value);
                                goto check1;
                        }
                }
                printf("The table after insertion is:\n");
                display();
        }
}
void modify()
{
        char variable[10];
        int result=0;
        printf("Enter the variable to be modified\n");
        scanf("%s",&variable);
        result=search(variable,n);
        if(result==0)
                printf("%s does not belong to table\n",variable);
        else
        {
                printf("The current value of the variable %s is %d\nEnter the new variable and its
                value\n",tbl[result].var,tbl[result].value);
                scanf("%s%d",tbl[result].var,&tbl[result].value);
                check:
                if(tbl[i].var[0]>='0'&&tbl[i].var[0]<='9')
                {
                        printf("The variable should start with an alphabet\nEnter correct variable name:\n");
                        scanf("%s%d",tbl[i].var,&tbl[i].value);
                        goto check;
                }
        }
        printf("The table after modification is:\n");
        display();
```

```
}
int search(char variable[],int n)
{
	int flag;
	for(i=1;i<=n;i++)
	{
		if(strcmp(tbl[i].var,variable)==0)
		{
			flag=1;
			break;
		}
	}
	if(flag==1)
		return i;
	else
		return 0;
}
void display()
{
	printf("VARIABLE\t VALUE\n");
	for(i=1;i<=n;i++)
		printf("%s\t\t%d\n",tbl[i].var,tbl[i].value);
}
```

OUTPUT

```
Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:1

Enter the no. of entries:3
Enter the variable and the value:
AIM             45
ASK             34
BALL                    56

The table after creation is:
VARIABLE                VALUE
AIM                     45
ASK                     34
BALL                     56

Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:2

Enter the value and variable
SIM             25

The table after insertion is:
VARIABLE        VALUE
AIM                      45
ASK                      34
BALL                     56
SIM                     25

Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:3


Enter the variable to be modified
ASK
The current value of the variable ASK is 34
```

```
Enter the new variable and its value
RIM                 40

The table after modification is:
VARIABLE        VALUE
AIM                     45
RIM                     40
BALL                    56
SIM                     25

Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:4

Enter the variable to be searched for:
RIM
The location of the variable is 2
The value of RIM is 40

Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:5

VARIABLE                VALUE
AIM                     45
RIM                     40
BALL                    56
SIM                     25
Enter your choice
1.Create
2.Insert
3.Modify
4.Search
5.Display
6.Exit:6
```

RESULT:

Thus the C program to implement Symbol Table was executed and verified successfully.

Ex.No :2

DATE:

DEVELOPMENT OF LEXICAL ANALYSER

AIM:

To develop a lexical analyzer to recognize a few patterns in C.

ALGORITHM:

1. Open the input file in read mode.
2. Read the string from file till end of file.
3. If the character is a slash then call skipcomment() for skip the comment statements in the file.
4. If the first string matches with any delimiters operator then print as a delimiter.
5. If the first string matches with any header then print that string as a header file.
6. If the first string matches with any operator then print that as an operator.
7. If the first string matches with any keywords then print that string as a keyword.
8. If the string is not a keyword then print that as an identifier.

PROGRAM:

```
/* This program is for creating a Lexical Analyzer.          lexical.c */
#include<stdio.h>
#include<string.h>                                  //Necessary Header files
#include<conio.h>
#include<ctype.h>
FILE *fp;                                           //File pointer for accessing the file
char delim[14]={' ','\t','\n',',',';','(',')','{','}','[',']','#','<','>'};
char oper[7]={'+','-','*','/','%','=','!'};//Array holding all the operators

/* Set of Keywords to check and list out */
char key[21][12]= {"int","float","char","double","bool","void","extern","unsigned","goto",
"static","class","struct","for","if","else","return","register","long","while","do"};

/*The Preprocessor directives*/
char predirect[2][12]={"include","define"};

/*The possible header files*/
char header[6][15]={"stdio.h","conio.h","malloc.h","process.h","string.h","ctype.h"};
void skipcomment();     //Function to skip comments.
void analyze();         //Function analyzing the input file
void check(char[]);     //Function to check whether the string matches any of the keywords
int isdelim(char);      //Function to check if the character retrieved from the file is a delimiter
int isop(char);   //Function to check if the character retrieved from the file is an operator
int fop=0,numflag=0,f=0;        //necessary flag values
char c,ch,sop;          //necessary character variables to store the characters retrieved

void main()                     //Main Function
{
        char fname[12];
        clrscr();
        printf("\nEnter filename : ");
        scanf("%s",fname);
        fp=fopen(fname,"r");    //Opening the file
        if(fp==NULL)            //Checking Existence of the File
                printf("\nThe file doesn't exist.");
```

```
        else                    //If Check succeeds
                analyze();
        printf("\nEnd of file\n");
        getch();
}                               //End of Main function

void analyze()                  //Analyse Function
{
        char token[50];  //Declare a token character array
        int j=0;
        while(!feof(fp)) //While the file is not over
        {
                c=getc(fp);
                if(c=='/')      //checking for comments in the file
                {
                        skipcomment(); //Function to skip comment statements
                }
                else if(c=="")          //Skipping printf statements and other such display
                        while((c=getc(fp))!="");
                else if(isalpha(c))     //checking if the character is an alphabet or not
                {
                        if(numflag==1)
                        {
                                token[j]='\0';
                                check(token);
                                numflag=0;
                                j=0;
                                f=0;
                        }
                        else
                        {
                                token[j]=c;     //Combining the characters to get the token
                                j++;
                        }
                        if(f==0)
                              f=1;
                }
```

```
else if(isalnum(c))
{
    if(numflag==0)
        numflag=1;
    token[j]=c;//combining the characters to get the token
    j++;
}
else
{
    if(isdelim(c))              //Checking for delimiters.
    {
        if(numflag==1)
        {
            token[j]='\0';
            check(token);
            numflag=0;
        }
        if(f==1)
        {
            token[j]='\0';
            numflag=0;
            check(token);
        }
        j=0;
        f=0;
        printf("\nDelimitter\t %c",c);
    }
    else if(isop(c))       //Checking for operators
    {
        if(numflag==1)
        {
            token[j]='\0';
            check(token);
            numflag=0;
            j=0;
            f=0;
        }
```

```
                    if(f==1)
                    {
                        token[j]='\0';
                        j=0;
                        f=0;
                        numflag=0;
                        check(token);
                    }
                if(fop==1)
                  {
                    fop=0;
                     printf("\nOperator\t %c%c",c,sop);   //In case the operator is like '++'or '--
                      }
                      else
                          printf("\nOperator\t %c",c);                    //In other cases.
            }
            else if(c=='.')
            {
                token[j]=c;
                j++;
            }
            }
        }
}

int isdelim(char c)         //Function to check if the character retrieved from the file is a delimiter.
{
        int i;
        for(i=0;i<14;i++)
        {
            if(c==delim[i])
                return 1;
        }
        return 0;
}

int isop(char c)  //Function to check if the character retrieved from the file is an operator.
```

```
{
        int i,j;
        char ch;
        for(i=0;i<7;i++)
        {
            if(c==oper[i])
            {
                ch=getc(fp);
                for(j=0;j<6;j++)                    //In case the operator is like '++' or '--', etc.
                {
                    if(ch==oper[j])
                    {
                        fop=1;
                        sop=ch;
                        return 1;
                    }
                }
                ungetc(ch,fp);
                return 1;
            }
        }
        return 0;
}
void check(char t[]) //Function to check if the token is an identifier, keyword, header file name
{
        int i;
        if(numflag==1)
        {
            printf("\nNumber\t\t %s",t);
            return;
        }
        for(i=0;i<2;i++)
        {
            if(strcmp(t,predirect[i])==0)
            {
                printf("\nPreprocessor directive %s",t);
                return;
```

```
            }
        }
        for(i=0;i<6;i++)
        {
            if(strcmp(t,header[i])==0)
            {
                printf("\nHeader file\t %s",t);
            return;
            }
        }
        for(i=0;i<21;i++)
        {
            if(strcmp(key[i],t)==0)
            {
                printf("\nKeyword\t\t %s",key[i]);
                return;
            }
        }
        printf("\nIdentifier\t %s",t);
}

void skipcomment()      //Function to skip over the comment statements in the file.
{
        ch=getc(fp);
        if(ch=='/')     //Checking single line comments
        {
            while((ch=getc(fp))!='\n');
        }
        else if(ch=='*') //Checking multiple line comments.
        {
            while(f==0)
            {
                ch=getc(fp);
                if(ch=='*')
                {
                    c=getc(fp);
                    if(c=='/')
```

```
                    f=1;
                }
            }
            f=0;
        }
}
```

INPUT FILE: iplex.c

```
#include<stdio.h>
#include<conio.h>
void main()
{
clrscr();
printf("Welcome\n");
getch();
}
```

OUTPUT

```
Enter filename : iplex.c

Delimitter      #
Preprocessor directive include
Delimitter      <
Header file     stdio.h
Delimitter      >
Delimitter

Delimitter      #
Preprocessor directive include
Delimitter      <
Header file     conio.h
Delimitter      >
Delimitter

Keyword         void
Delimitter
Identifier      main
```

Delimitter (
Delimitter)
Delimitter

Delimitter {
Delimitter

Identifier clrscr
Delimitter (
Delimitter)
Delimitter ;
Delimitter

Identifier printf
Delimitter (
Delimitter)
Delimitter ;
Delimitter
Identifier getch
Delimitter (
Delimitter)
Delimitter ;
Delimitter
Delimitter }
End of file

RESULT

Thus the C program for implementation of a lexical analyzer to recognize a few patterns was executed and verified successfully.

Ex. No: 3
DATE:

IMPLEMENTATION OF LEXICAL ANALYSER USING LEX TOOL

AIM:

To write a 'C' program to implement a lexical analyzer for separation of tokens using LEX Tool.

ALGORITHM:

Step 1: Declare and Initialize the required variable.

Step 2: If the statement starts with #.* print it as preprocessor directive.

Step 3: Check for the given list of keywords and print them as keyword if it is encountered.

Step 4: If the given string is '/*' or '*/' print it as comment line.

Step 5: For a function, print the beginning and ending of the function block.

Step 6: Similarly print the corresponding statements for numbers, identifiers and assignment operators.

Step 7: In the main function get the input file as argument and open the file in read mode.

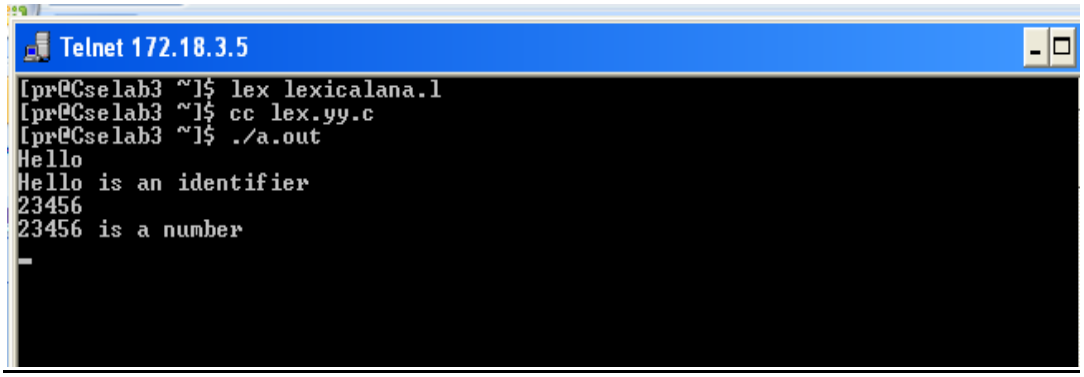
Step 8: Then read the file and print the corresponding lex statement given above.

PROGRAM 1:

Program Name: id.l

```
%{
        #include<stdio.h>
%}

%%
        if|else|while|int|switch|for        {printf("%s is a keyword",yytext);}
        [a-z|A-Z]([a-z|A-Z]|[0-9])*         {printf("%s is an identifier",yytext);}
        [0-9]*                              {printf("%s is a number",yytext);}
%%
int main()
{
        yylex();
        return 0;
}
int yywrap()
{
}
```

OUTPUT



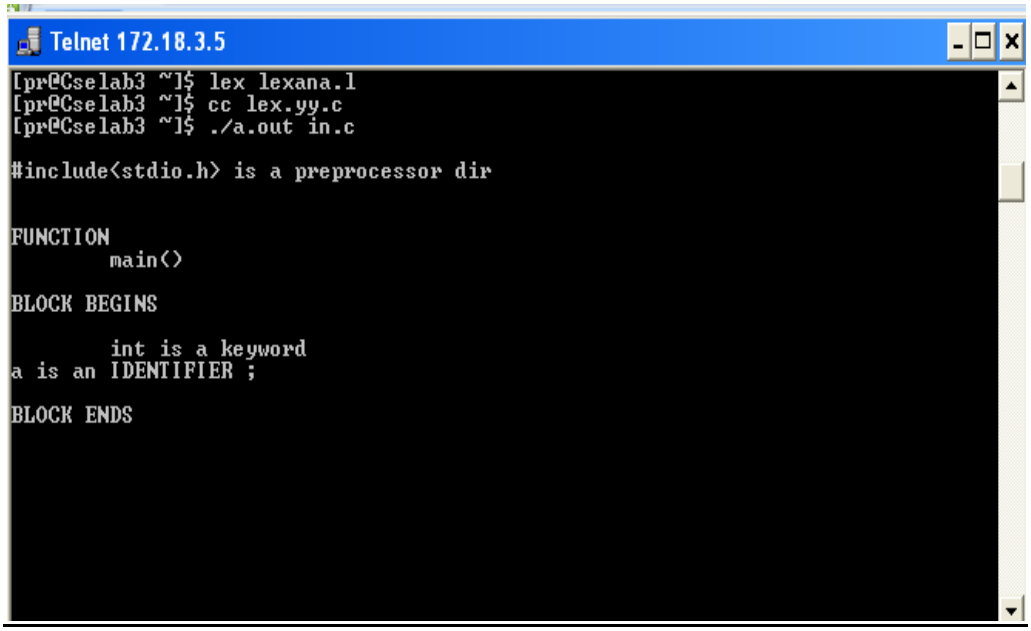
PROGRAM 2:

```
%{
%}
identifier [a-z|A-Z]|[a-z|A-Z|0-9]*

%%
        #.*                             {printf("\n%s is a preprocessor dir",yytext);}
        int                             {printf("\n\t%s is a keyword",yytext);}
        {identifier}\(          {printf("\n\nFUNCTION\n\t%s",yytext);}
        \{                              {printf("\nBLOCK BEGINS");}
        \}                              {printf("\nBLOCK ENDS");}
        {identifier}            {printf("\n%s is an IDENTIFIER",yytext);}
        . | \n
%%

int main(int argc,char **argv)
{
        if(argc>1)
        {
                FILE *file;
                file=fopen(argv[1],"r");
                if(!file)
                {
                        printf("\n couldnot open %s\n",argv[1]);
                        exit(0);
                }
                yyin=file;
        }
        yylex();
        printf("\n\n");
        return 0;
}

int yywrap()
{
        return 0;
}
```

Input (in.c)

```
#include<stdio.h>
main()
{
        int a ;
}
```

OUTPUT:



RESULT:

Thus the C program for the implementation of lexical analyzer using LEX Tool was executed successfully.

Ex. No: 4 (a)
DATE:

GENERARATION OF YACC SPECIFICATION RECOGNIZING A VALID ARITHMETIC EXPRESSION

AIM:

To write a program to recognize a valid arithmetic expression that uses operator +, - , * and / using YACC tool.

ALGORITHM:

LEX

1. Declare the required header file and variable declaration with in '%{' and '%}'.
2. LEX requires regular expressions to identify valid arithmetic expression token of lexemes.
3. LEX call **yywrap()** function after input is over. It should return 1 when work is done or should return 0 when more processing is required.

YACC

1. Declare the required header file and variable declaration with in '%{' and '%}'.
2. Define tokens in the first section and also define the **associativity** of the operations
3. Mention the grammar productions and the action for each production.
4. **$$** refer to the top of the stack position while **$1** for the first value, **$2** for the second value in the stack.
5. Call **yyparse()** to initiate the parsing process.
6. **yyerror()** function is called when all productions in the grammar in second section doesn't match to the input statement.

PROGRAM:

//art_expr.l

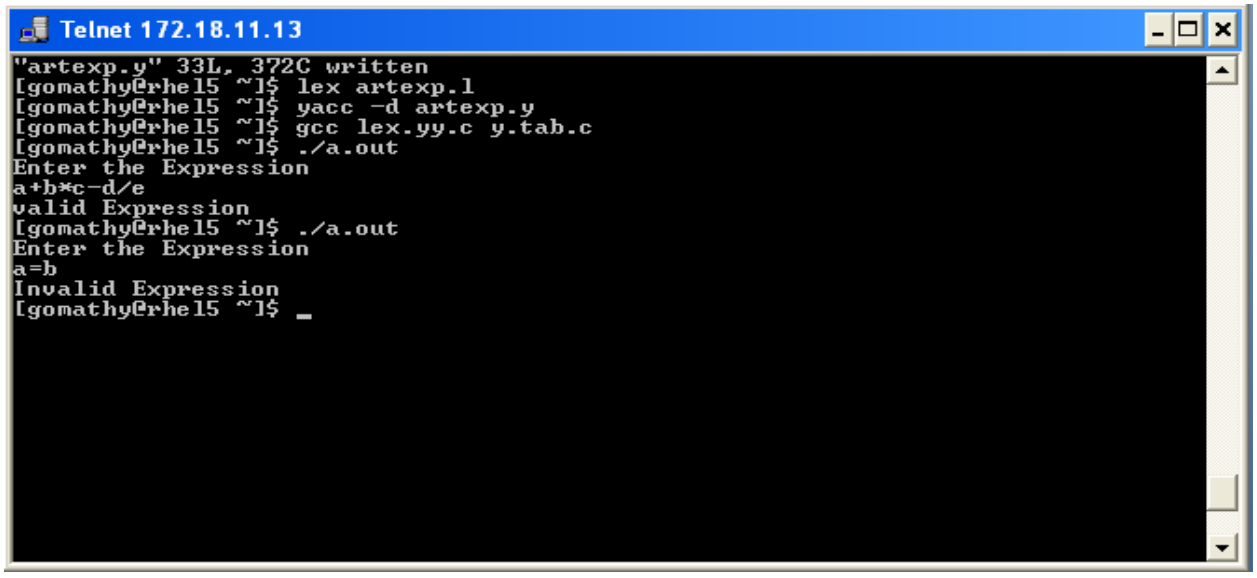
```
%{
        #include<stdio.h>
        #include "y.tab.h"
%}
%%
        [a-zA-Z][0-9a-zA-Z]* {return ID;}
        [0-9]+  {return DIG;}
        [ \t]+ {;}
        .  {return yytext[0];}
        \n {return 0;}
%%
int yywrap()
{
        return 1;
}
```

//art_expr.y

```
%{
        #include<stdio.h>
%}
%token ID DIG
%left '+"-'
%left '*"/'
%right UMINUS
%%
        stmt:expn ;
        expn:expn'+'expn
        |expn'-'expn
        |expn'*'expn
        |expn'/'expn
        |'-'expn %prec UMINUS
        |'('expn')'
        |DIG
        |ID
```

```
        ;
%%
int main()
{
        printf("Enter the Expression \n");
        yyparse();
        printf("valid Expression \n");
        return 0;
}
int yyerror()
{
        printf("Invalid Expression");
        exit(0);
}
```

OUTPUT



RESULT:

Thus the program to recognize a valid arithmetic expression that uses operator +, - , * and / using YACC tool was executed and verified successfully.

Ex. No: 4 (b)
DATE:

RECOGNIZING A VALID VARIABLE

AIM:

To write a program to recognize a valid variable which starts with a letter followed by any number of letters or digits using YACC tool.

ALGORITHM:

LEX

1. Declare the required header file and variable declaration with in '%{' and '%}'.
2. LEX requires regular expressions or patterns to identify token of lexemes for recognize a valid variable.
3. Lex call **yywrap()** function after input is over. It should return 1 when work is done or should return 0 when more processing is required.

YACC

1. Declare the required header file and variable declaration with in '%{' and '%}'.
2. Define tokens in the first section and also define the **associativity** of the operations
3. Mention the grammar productions and the action for each production.
4. **$$** refer to the top of the stack position while **$1** for the first value, **$2** for the second value in the stack.
5. Call **yyparse()** to initiate the parsing process.
6. **yyerror()** function is called when all productions in the grammar in second section doesn't match to the input statement.

PROGRAM:

//valvar.l

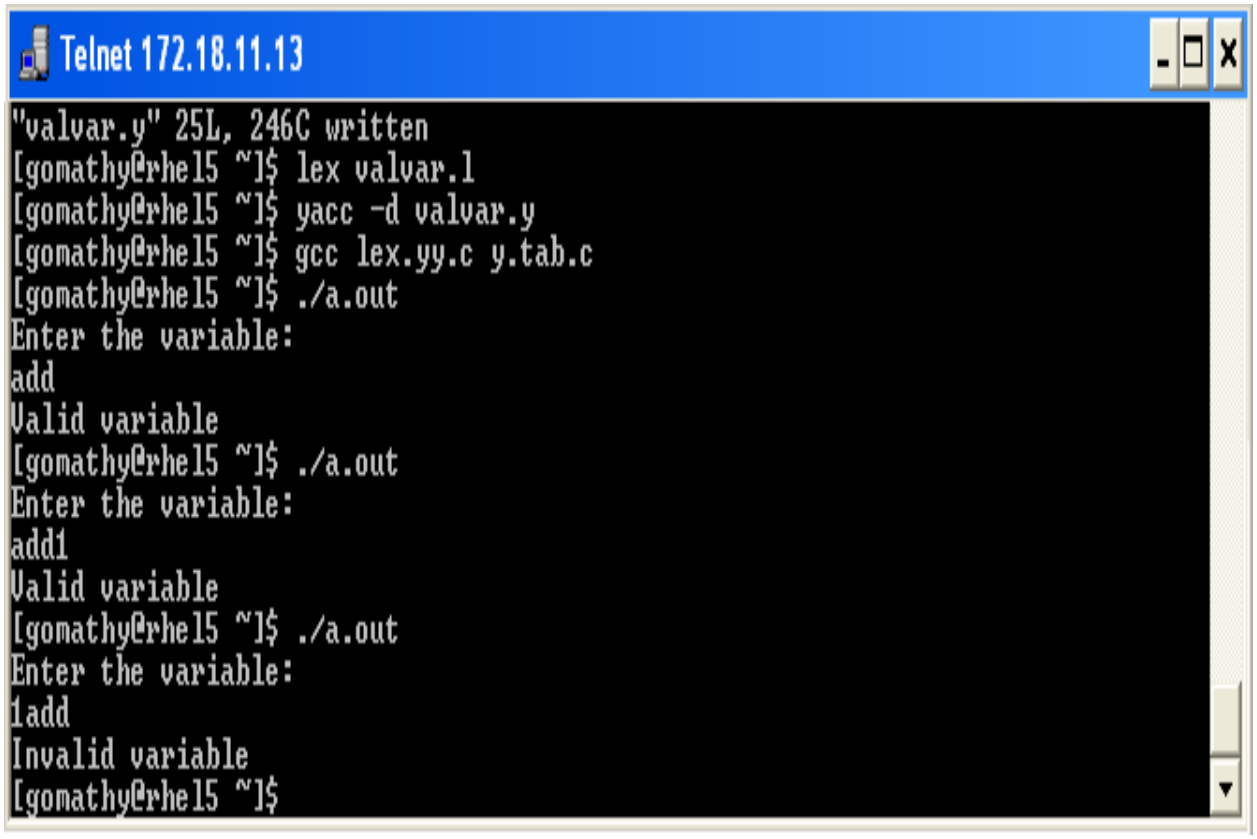
```
%{
        #include "y.tab.h"
%}
%%
        [a-zA-Z]     {return LET;}
        [0-9]        {return DIG;}
        .            {return yytext[0];}
        \n           {return 0;}
%%
int yywrap()
{
        return 1;
}
```

//valvar.y

```
%{
        #include<stdio.h>
%}
%token LET DIG
%%
        variable:var
        ;
        var:var DIG
        |var LET
        |LET
        ;
%%
int main()
{
        printf("Enter the variable:\n");
        yyparse();
        printf("Valid variable \n");
```

```
        return 0;
}
int yyerror()
{
        printf("Invalid variable \n");
        exit(0);
}
```

OUTPUT:



RESULT:

Thus the program to recognize a valid variable which starts with a letter followed by any number of letters or digits using YACC tool was executed and verified successfully.

Ex.NO: 4(c)

DATE:

IMPLEMENTATION OF CALCULATOR USING LEX AND YACC

AIM:

To write a program to implement Calculator using LEX and YACC.

ALGORITHM:

Step 1: Start the program.

Step 2: In the declaration part of lex, includes declaration of regular definitions as digit.

Step 3: In the translation rules part of lex, specifies the pattern and its action that is to be executed whenever a lexeme matched by pattern is found in the input in the cal.l.

Step 4: By use of Yacc program,all the Arithmetic operations are done such as +,-,*,/.

Step 5: Display error is persist.

Step 6: Provide the input.

Step 7: Verify the output.

Step 8: End.

PROGRAM:

cal.l

```
DIGIT  [0-9]+

%option noyywrap

%%

{DIGIT}          { yylval=atof(yytext);    return NUM;}
\n|.             { return yytext[0];}

%%
```

cal.y

```
%{
        #include<ctype.h>
        #include<stdio.h>
        #define YYSTYPE double
%}

%token NUM
%left '+' '-'
%left '*' '/'
%right UMINUS


%%

Statment:E { printf("Answer: %g \n", $$); }
        |Statment '\n'
        ;
E       : E'+'E { $$ = $1 + $3; }
        | E'-'E { $$=$1-$3; }
        | E'*'E { $$=$1*$3; }
        | E'/'E { $$=$1/$3; }
        | NUM
        ;
%%
```

OUTPUT:

```
"cal2.y" 59L, 1186C written
[exam01@Cselab3 ~]$ lex cal2.l
[exam01@Cselab3 ~]$ yacc yaccal2.y
[exam01@Cselab3 ~]$ cc y.tab.c
[exam01@Cselab3 ~]$ ./a.out
Enter the expression:2+2
Answer: 4
```

RESULT:

Thus the program for implementing calculator using LEX and YACC is executed and verified.

Ex.No:5

DATE:

CONVERSION OF THE BNF RULES INTO YACC FORM AND GENERATION ABSTRACT SYNTAX TREE

AIM:

To write the program to convert the BNF rules into YACC form and write code to generate abstract syntax tree.

ALGORITHM:

1. Start the program.
2. Reading an input file line by line.
3. Convert it in to abstract syntax tree using three address codes.
4. Represent three address codes in the form of quadruple tabular form.

PROGRAM:

<int.l>

```
%{
        #include"y.tab.h"
        #include<stdio.h>
        #include<string.h>
        int LineNo=1;
%}
identifier [a-zA-Z][_a-zA-Z0-9]*
number [0-9]+|([0-9]*\.[0-9]+)
%%
        main\(\) return MAIN;
        if return IF;
        else return ELSE;
        while return WHILE;
        int |
        char |
        float return TYPE;
        {identifier} {strcpy(yylval.var,yytext);
        return VAR;}
        {number} {strcpy(yylval.var,yytext);
        return NUM;}
        \< |
        \> |
        \>= |
        \<= |
        == {strcpy(yylval.var,yytext);
        return RELOP;}
        [ \t] ;
        \n LineNo++;
        . return yytext[0];
%%
```

<**int.y**>

```
%{
        #include<string.h>
        #include<stdio.h>
        struct quad
        {
                char op[5];
                char arg1[10];
                char arg2[10];
                char result[10];
        }QUAD[30];
        struct stack
        {
                int items[100];
                int top;
        }stk;
        int Index=0,tIndex=0,StNo,Ind,tInd;
        extern int LineNo;
%}
%union
```

```
{
        char var[10];
}
%token <var> NUM VAR RELOP
%token MAIN IF ELSE WHILE TYPE
%type <var> EXPR ASSIGNMENT CONDITION IFST ELSEST WHILELOOP
%left '-' '+'
%left '*' '/'
%%
        PROGRAM : MAIN BLOCK
        ;
        BLOCK : '{' CODE '}'
        ;
        CODE: BLOCK
        | STATEMENT CODE
        | STATEMENT
        ;
        STATEMENT: DESCT ';'
        | ASSIGNMENT ';'
        | CONDST
        | WHILEST
        ;
        DESCT: TYPE VARLIST
        ;
        VARLIST: VAR ',' VARLIST
        | VAR
        ;
        ASSIGNMENT: VAR '=' EXPR{
        strcpy(QUAD[Index].op,"=");
        strcpy(QUAD[Index].arg1,$3);
        strcpy(QUAD[Index].arg2,"");
        strcpy(QUAD[Index].result,$1);
        strcpy($$,QUAD[Index++].result);
        }
        ;
        EXPR: EXPR '+' EXPR {AddQuadruple("+",$1,$3,$$);}
        | EXPR '-' EXPR {AddQuadruple("-",$1,$3,$$);}
        | EXPR '*' EXPR {AddQuadruple("*",$1,$3,$$);}
        | EXPR '/' EXPR {AddQuadruple("/",$1,$3,$$);}
        | '-' EXPR {AddQuadruple("UMIN",$2,"",$$);}
        | '(' EXPR ')' {strcpy($$,$2);}
        | VAR
        | NUM
        ;
        CONDST: IFST{
        Ind=pop();
        sprintf(QUAD[Ind].result,"%d",Index);
        Ind=pop();
        sprintf(QUAD[Ind].result,"%d",Index);
        }
        | IFST ELSEST
        ;
        IFST: IF '(' CONDITION ')' {
        strcpy(QUAD[Index].op,"==");
        strcpy(QUAD[Index].arg1,$3);
```

```
        strcpy(QUAD[Index].arg2,"FALSE");
        strcpy(QUAD[Index].result,"-1");
        push(Index);
        Index++;
        }
        BLOCK {
        strcpy(QUAD[Index].op,"GOTO");
        strcpy(QUAD[Index].arg1,"");
        strcpy(QUAD[Index].arg2,"");
        strcpy(QUAD[Index].result,"-1");
        push(Index);
        Index++;
        };
        ELSEST: ELSE{
        tInd=pop();
        Ind=pop();
        push(tInd);
        sprintf(QUAD[Ind].result,"%d",Index);
        }
        BLOCK{
        Ind=pop();
        sprintf(QUAD[Ind].result,"%d",Index);
        };
        CONDITION: VAR RELOP VAR {AddQuadruple($2,$1,$3,$$);
        StNo=Index-1;
        }
        | VAR
        | NUM
        ;
        WHILEST: WHILELOOP{
        Ind=pop();
        sprintf(QUAD[Ind].result,"%d",StNo);
        Ind=pop();
        sprintf(QUAD[Ind].result,"%d",Index);
        }
        ;
        WHILELOOP: WHILE '(' CONDITION ')' {
        strcpy(QUAD[Index].op,"==");
        strcpy(QUAD[Index].arg1,$3);
        strcpy(QUAD[Index].arg2,"FALSE");
        strcpy(QUAD[Index].result,"-1");
        push(Index);
        Index++;
        }
        BLOCK {
        strcpy(QUAD[Index].op,"GOTO");
        strcpy(QUAD[Index].arg1,"");
        strcpy(QUAD[Index].arg2,"");
        strcpy(QUAD[Index].result,"-1");
        push(Index);
        Index++;
        }
        ;
%%
extern FILE *yyin;
```

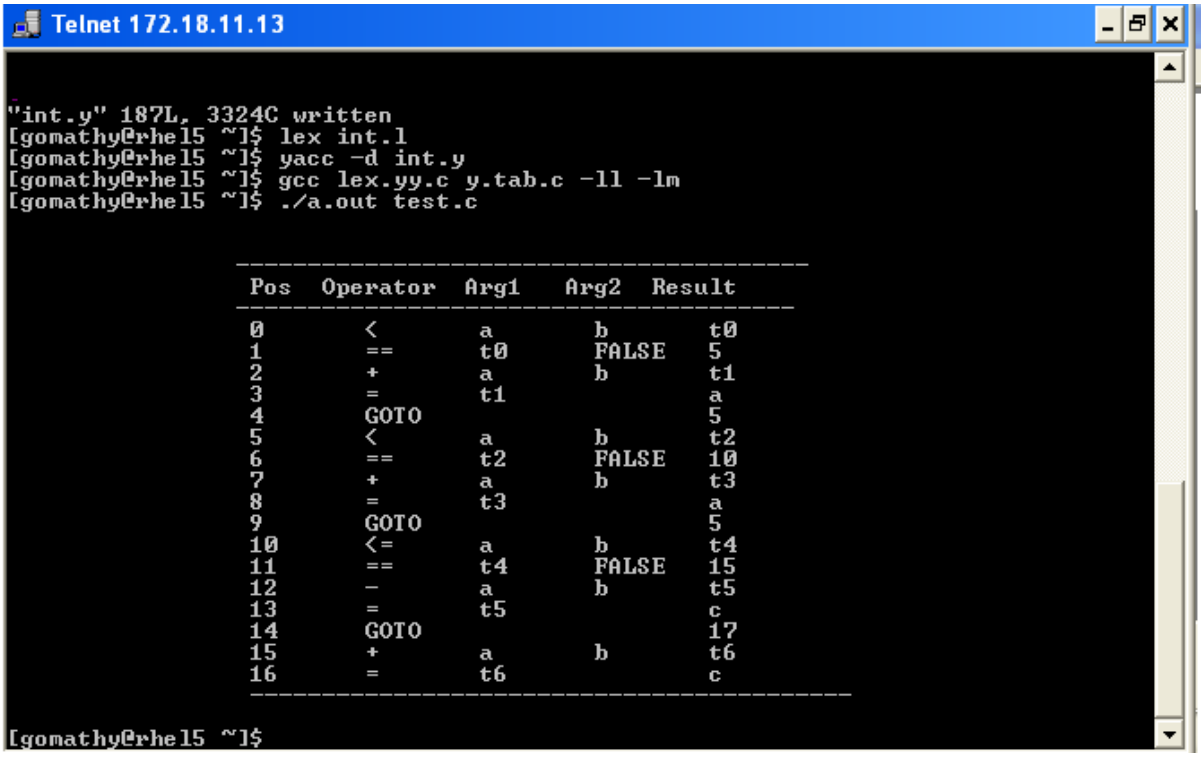
```
int main(int argc,char *argv[])
{
	FILE *fp;
	int i;
	if(argc>1)
	{
		fp=fopen(argv[1],"r");
		if(!fp)
		{
			printf("\n File not found");
			exit(0);
		}
		yyin=fp;
	}
	yyparse();
	printf("\n\n\t\t ----------------------------""\n\t\t Pos Operator Arg1 Arg2 Result" "\n\t\t
	--------------------");
	for(i=0;i<Index;i++)
	{
		printf("\n\t\t %d\t %s\t %s\t %s\t
		%s",i,QUAD[i].op,QUAD[i].arg1,QUAD[i].arg2,QUAD[i].result);
	}
	printf("\n\t\t ------------------------");
	printf("\n\n");
	return 0;
}
void push(int data)
{
	stk.top++;
	if(stk.top==100)
	{
		printf("\n Stack overflow\n");
		exit(0);
	}
	stk.items[stk.top]=data;
}
int pop()
{
	int data;
	if(stk.top==-1)
	{
		printf("\n Stack underflow\n");
		exit(0);
	}
	data=stk.items[stk.top--];
	return data;
}
void AddQuadruple(char op[5],char arg1[10],char arg2[10],char result[10])
{
	strcpy(QUAD[Index].op,op);
	strcpy(QUAD[Index].arg1,arg1);
	strcpy(QUAD[Index].arg2,arg2);
	sprintf(QUAD[Index].result,"t%d",tIndex++);
	strcpy(result,QUAD[Index++].result);
}
```

```
yyerror()
{
	printf("\n Error on line no:%d",LineNo);
}
```

Input

```
$vi test.c
main()
{
	int a,b,c;
	if(a<b)
	{
		a=a+b;
	}
	while(a<b)
	{
		a=a+b;
	}
	if(a<=b)
	{
		c=a-b;
	}
	else
	{
		c=a+b;
	}
}
```

OUTPUT:



RESULT:

Thus the program to convert the BNF rules into YACC forms and writes code to generate abstract syntax tree was executed successfully.

Ex.No: 6

DATE:

IMPLEMENTATION OF TYPE CHECKING

AIM:

To write a C program to implement type checking.

ALGORITHM:

1. Start the program for type checking of given expression
2. Read the expression and declaration
3. Based on the declaration part define the symbol table
4. Check whether the symbols present in the symbol table or not. If it is found in the symbol table it displays "Label already defined".
5. Read the data type of the operand 1, operand 2 and result in the symbol table.
6. If the both the operands' type are matched then check for result variable. Else, print "Type mismatch".
7. If all the data type are matched then displays "No type mismatch".

PROGRAM:

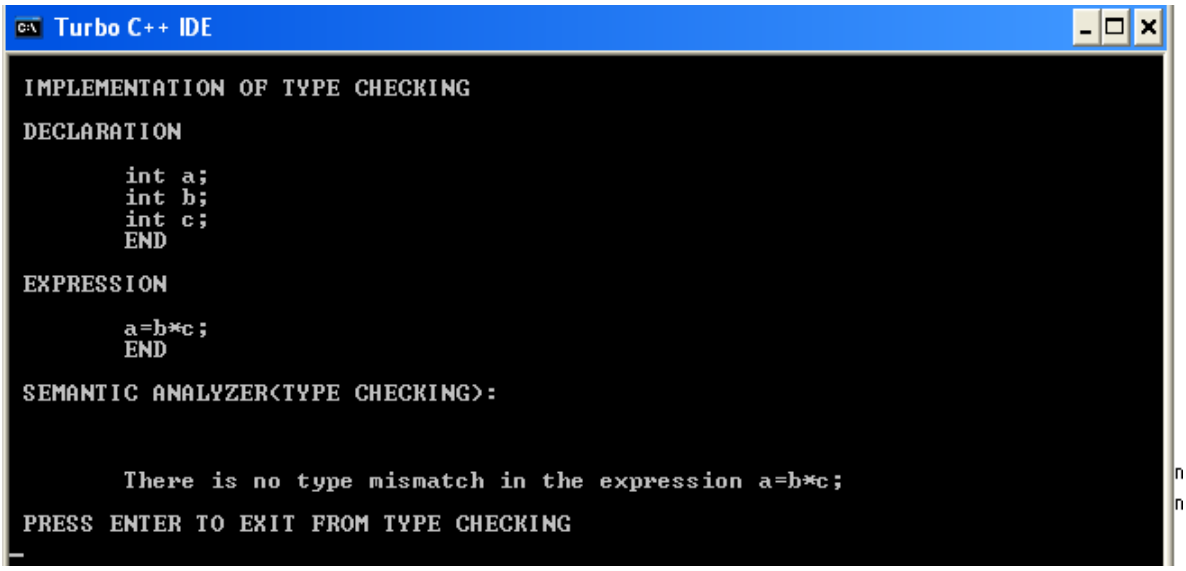
```
#include<stdio.h>
#include<string.h>
#include<conio.h>
int count=1,i=0,j=0,l=0,findval=0,k=0,kflag=0;
char key[4][12]= {"int","float","char","double"};
char dstr[100][100],estr[100][100];
char token[100],resultvardt[100],arg1dt[100],arg2dt[100];
void entry();
int check(char[]);
int search(char[]);
void typecheck();

struct table
{
char var[10];
char dt[10];
};
struct table tbl[20];

void main()
{
        clrscr();
        printf("\n IMPLEMENTATION OF TYPE CHECKING \n");

        printf("\n DECLARATION \n\n");
        do
        {
                printf("\t");
                gets(dstr[i]);
                i++;
        } while(strcmp(dstr[i-1],"END"));
        printf("\n EXPRESSION \n\n");
        do
        {
                printf("\t");
                gets(estr[l]);
                l++;
        }while(strcmp(estr[l-1],"END"));

        i=0;
        printf("\n SEMANTIC ANALYZER(TYPE CHECKING): \n");
        while(strcmp(dstr[i],"END"))
        {
                 entry();
                 printf("\n");
                 i++;
        }
        l=0;
        while(strcmp(estr[l],"END"))
        {
                typecheck();
                printf("\n");
```

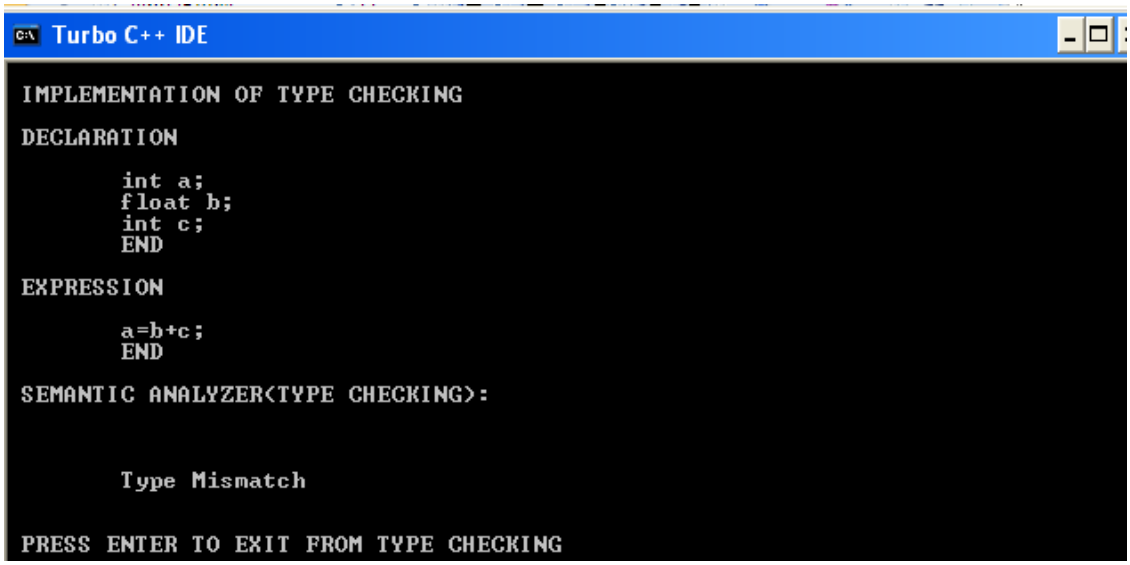
```
                l++;
        }

        printf("\n PRESS ENTER TO EXIT FROM TYPE CHECKING\n");
        getch();
}
void entry()
{
        j=0;
        k=0;
        memset(token,0,sizeof(token));
        while(dstr[i][j]!=' ')
        {
                token[k]=dstr[i][j];
                k++;
                j++;
        }
        kflag=check(token);
        if(kflag==1)
        {
                strcpy(tbl[count].dt,token);
                k=0;
                memset(token,0,strlen(token));
                j++;
                while(dstr[i][j]!=';')
                {
                        token[k]=dstr[i][j];
                        k++;
                        j++;
                }
                findval=search(token);
                if(findval==0)
                {
                        strcpy(tbl[count].var,token);
                }
                else
                {
                        printf("The variable %s is already declared",token);
                }
                kflag=0;
                count++;
        }
        else
        {
                printf("Enter valid datatype\n");
        }

}

void typecheck()
{
        memset(token,0,strlen(token));
        j=0;
        k=0;
        while(estr[l][j]!='=')
```

```
{
        token[k]=estr[l][j];
        k++;
        j++;
}
findval=search(token);
if(findval>0)
{
        strcpy(resultvardt,tbl[findval].dt);
        findval=0;
}
else
{
        printf("Undefined Variable\n");
}
k=0;
memset(token,0,strlen(token));
j++;
while(((estr[l][j]!='+')&&(estr[l][j]!='-')&&(estr[l][j]!='*')&&(estr[l][j]!='/')))
{
        token[k]=estr[l][j];
        k++;
        j++;
}
findval=search(token);
if(findval>0)
{
        strcpy(arg1dt,tbl[findval].dt);
        findval=0;
}
else
{
        printf("Undefined Variable\n");
}
k=0;
memset(token,0,strlen(token));
j++;
while(estr[l][j]!=';')
{
        token[k]=estr[l][j];
        k++;
        j++;
}
findval=search(token);
if(findval>0)
{
        strcpy(arg2dt,tbl[findval].dt);
        findval=0;
}
else
{
        printf("Undefined Variable\n");
}
if(!strcmp(arg1dt,arg2dt))
{
```

```
                if(!strcmp(resultvardt,arg1dt))
                {
                        printf("\tThere is no type mismatch in the expression %s ",estr[l]);
                }
                else
                {
                        printf("\tLvalue and Rvalue should be same\n");
                }
        }
        else
        {
                printf("\tType Mismatch\n");
        }
}

int search(char variable[])
{
        int i;
        for(i=1;i<=count;i++)
        {
                if(strcmp(tbl[i].var,variable) == 0)
                {
                        return i;
                }
        }
        return 0;
}

int check(char t[])
{
        int in;
        for(in=0;in<4;in++)
        {
                if(strcmp(key[in],t)==0)
                {
                        return 1;
                }
        }
        return 0;
}
```

OUTPUT:





RESULT:

Thus the program for type checking is executed and verified.

Ex.No: 7

DATE:

CONSTRUCTION OF DAG

AIM:

To write a C program to construct DAG.

ALGORITHM:

1) Read the intermediate code as input from the file.
2) Store the argument1 as left node and argument2 as right node.
3) Attach the result variable to the root node of an expression.
4) Use the same node if the variable and values are same.
5) Finally construct the DAG

PROGRAM:

```
#include<stdio.h>
#include <conio.h>
struct node
{
        struct node *next;
        char id[10];
        char left[10];
        char right[10];
        char attach[3][10];
};
struct node *head;
FILE *f;
int i,s=0;
char str[25],store[10][25];
void construct_tree()
{
        struct node *temp;
        struct node *t;
        struct node *ptr;
        int flag=0,f1=0;
        temp=head;
        if(s==5||s==6)
        {
                while (temp->next!=NULL)
                {
                        if(!strcmp(store[2],temp->next->left))
```

```
                flag+=1;
        if(!strcmp(store[4],temp->next->right))
                flag+=2;
        if(flag!=0)
                break;
        temp=temp->next;
}
t=head;
while(t->next!=NULL)
        t=t->next;
if(flag==0)
{
        ptr=(struct node*)malloc(sizeof(struct node));
        t->next=ptr;
        if(s==5)
                strcpy(ptr->id,store[3]);
        else
                strcpy(ptr->id,strcat(store[3],store[5]));
        t=head;
        while(t->next!=NULL)
        {
                if(!strcmp(t->next->attach[0],store[2]))
                {
                        f1=1;
                        break;
                }
                if(strcmp(t->next->attach[1],""))
                if(!strcmp(t->next->attach[1],store[2]))
```

```
            {
                f1=1;
                break;
            }
            t=t->next;
        }
        if(f1)
            strcpy(ptr->left,t->next->id);
        else
            strcpy(ptr->left,store[2]);
        f1=0;
        t=head;
        while(t->next!=NULL)
        {
            if(!strcmp(t->next->attach[0],store[4]))
            {
                f1=1;
                break;
            }
            if(strcmp(t->next->attach[1],""))
            if(!strcmp(t->next->attach[1],store[4]))
            {
                f1=1;
                break;
            }
            t=t->next;
        }
        if(f1)
```

```
                        strcpy(ptr->right,t->next->id);
                else
                        strcpy(ptr->right,store[0]);
                        strcpy(ptr->attach[1],"");
                        ptr->next=NULL;
                }
                else if(flag==3)
                        strcpy(temp->next->attach[1],store[0]);
        }
        if(s==3)
        {
        while(temp->next!=NULL)
        {
                if(!strcmp(store[2],temp->next->attach[0]))
                        break;
                temp=temp->next;
        }
        strcpy(temp->next->attach[1],store[0]);
    }
}

int main()
{
    struct node *temp;
    struct node *t;
    clrscr();
    f=fopen("C:\\DAG.txt","r");
    head=(struct node*)malloc(sizeof(struct node));
```

```
	head->next=NULL;
	while(!feof(f))
	{
		fscanf(f,"%s",str);
		if(!strcmp(str,";"))
		{
			construct_tree();
			s=0;
		}
		else
			strcpy(store[s++],str);
		}
	printf("\n\nID\tLEFT\tRIGHT\tATTACHED IDs\n\n");
	temp=head;
	while(temp->next!=NULL)
	{
		printf("\n\n%s\t%s\t%s\t%s\t",temp->next->id,
		temp->next->left,temp->next->right,temp->next->attach[0]);
		if(strcmp(temp->next->attach[1],""))
			printf("\t%s",temp->next->attach[1]);
		temp=temp->next;
	}
	getch();
	return 0;
}
```

INPUT:

```
t1=4*i;
t2=a[t1];
t3=4*i;
t4=b[t3];
t5=t2*t4;
t6=prod+t5;
prod=t6;
t7=i+1;
i=t7;
```

OUTPUT:

ID	LEFT	RIGHT	ATTACHED	IDs
*	4	I	t1	t3
[]	a	*	t2	
[]	b	*	t4	
*	[]	[]	t5	
+	prod	*	t6	prod
+	I		t7	i

RESULT:

Thus the program for construction of DAG is executed and verified.

Ex.No: 8

DATE:

IMPLEMENTATION OF STACK

AIM:

To implement a storage allocation using stack.

ALGORITHM:

1) Get the size of the stack.
2) Read the choice of operation.
3) If the choice is 1push the items into the stack
4) To push the elements perform the following.
    a) If the top of stack is equal to size of stack elements can't be pushed.
    b) Read item to be pushed.
    c) Set or increment the top by one.
    d) Assign the item to the stack [top].
    e) Repeat the steps until it is required.
5) If choice is 2 pop the items from the stack
    a) Check for empty stack.
    b) Decrement the top by one.
    c) Return the popped item.
6) If choice is 3 display the contents of Stack.

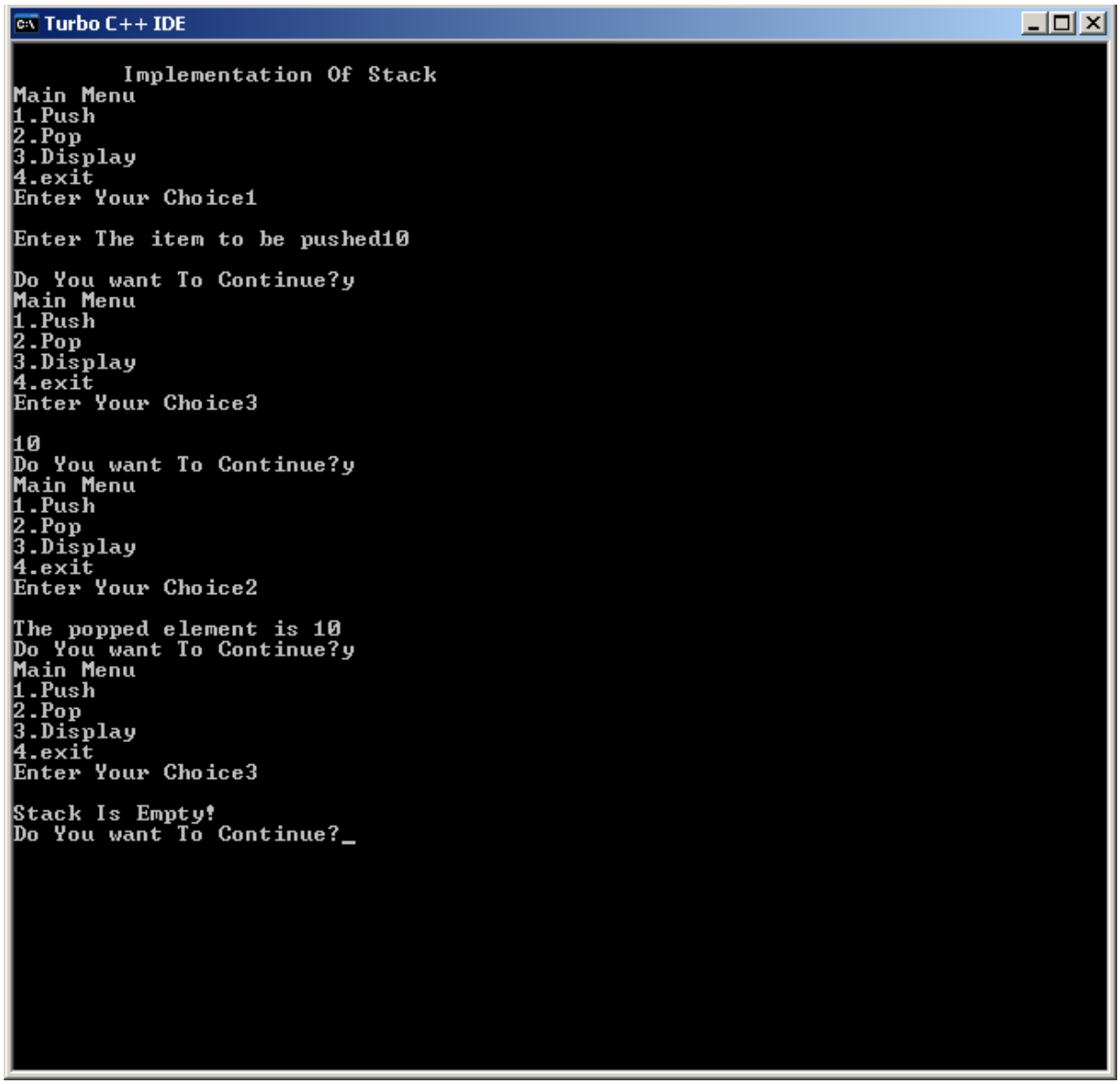
PROGRAM:

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

#define size 5
struct stack
{
        int s[size];
        int top;
} st;

int stfull()
{
        if(st.top>=size-1)
        return 1;
        else
        return 0;
}

void push(int item)
{
        st.top++;
        st.s[st.top] = item;
}

int stempty()
{
        if(st.top==-1)
                return 1;
        else
                return 0;
}

int pop()
{
        int item;
        item = st.s[st.top];
        st.top--;
        return (item);
}

void display()
{
        int i;
        if(stempty())
        printf("\nStack Is Empty!");
        else
```

```
	{
		for(i=st.top;i>=0;i--)
			printf("\n%d",st.s[i]);
	}
}

int main()
{
	int item, choice;
	char ans;
	st.top = -1;

	printf("\n\tImplementation Of Stack");
	do
	{
		printf("\nMain Menu");
		printf("\n1.Push \n2.Pop \n3.Display \n4.exit");
		printf("\nEnter Your Choice");
		scanf("%d", &choice);
		switch (choice)
		{
			case 1:
				printf("\nEnter The item to be pushed");
				scanf("%d", &item);
				if (stfull())
					printf("\nStack is Full!");
				else
					push(item);
					break;
			case 2:
				if(stempty())
					printf("\nEmpty stack!Underflow !!");
				else
				{
					item = pop();
					printf("\nThe popped element is %d", item);
				}
				break;
			case 3:
				display();
				break;
			case 4:
				exit(0);
		}
	printf("\nDo You want To Continue?");
	ans=getche();
}
while(ans=='Y'||ans =='y');
```

return 0;
}

OUTPUT:



RESULT:

Thus the program for stack implementation is executed and verified.

Ex.No: 9
DATE:

IMPLEMENTATION OF BACKEND

AIM:

To write a 'C' program to generate the machine code for the given intermediate code.

ALGORITHM:

Step1: Get the input expression from the user.

Step2: The given expression is transformed into tokens.

Step3: Display the assembly code according to the operators present in the given expression.

Step4: Use the temporary registers (R0, R1) while storing the values in assembly code programs.

PROGRAM:

```
/* CODE GENERATOR */
#include<stdio.h>
#include<string.h>
int count=0,i=0,l=0;
char str[100][100];
void gen();

void main()
{
        clrscr();
        printf("\n CODE GENERATOR \n");
        printf("\n ENTER THREE ADDRESS CODE \n\n");
        do
        {
                printf("\t");
                gets(str[i]);
                i++;
        } while(strcmp(str[i-1],"QUIT"));

        i=0;
        printf("\n ASSEMBLY LANGUAGE CODE: \n");
                while(strcmp(str[i-1],"QUIT"))
                {
                   gen();
                        printf("\n");
                   i++;
                }

        printf("\n PRESS ENTER TO EXIT FROM CODE GENERATOR\n");
        getch();
}

void gen()
{
        int j;
        printf("\n");
        for(j=strlen(str[i])-1;j>=0;j--)
        {
            char reg='R';
            if(isdigit(str[i][j])||(isalpha(str[i][j]))|| str[i][j]=='+'||str[i][j]=='-'||str[i][j]=='*'||str[i][j]=='/'||str[i][j]=='
'||str[i][j]=='|'||str[i][j]=='&'||str[i][j]==':'||str[i][j]=='=')
                {
                        switch(str[i][j])
                        {
                                case '+':
                                        printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
```

```
                                printf("\n\t ADD\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case '-':
                                printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
                                printf("\n\t SUB\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case '*':
                                printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
                                printf("\n\t MUL\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case '/':
                                printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
                                printf("\n\t DIV\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case '|':
                                printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
                                printf("\n\t OR\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case '&':
                                printf("\n\t MOV\t%c,%c%d",str[i][j-1],reg,count);
                                printf("\n\t AND\t%c,%c%d",str[i][j+1],reg,count);
                                break;
                        case ':':
                                if(str[i][j+1]=='=')
                                {
                                  printf("\n\t MOV\t%c%d,%c",reg,count,str[i][j-1]);
                                  count++;
                                }
                                else
                                {
                                   printf("\n syntax error...\n");
                                }
                                break;
                        default:
                                break;
                        }
                }
                else printf("\n Error\n");
}
}
```

OUTPUT:

CODE GENERATOR

ENTER THREE ADDRESS CODE

A:=B+C

D:=E/F

QUIT

ASSEMBLY LANGUAGE CODE:

MOV B,R0

ADD C,R0

MOV R0,A

MOV E,R1

DIV F,R1

MOV R1,D

PRESS ENTER TO EXIT FROM CODE GENERATOR

RESULT:

Thus the program for generation of Machine Code for the given intermediate code is executed and verified.

Ex.No:10

DATE:

IMPLEMENTATION OF CODE OPTMIZATION TECHNIQUES

AIM:

To write a C program to implement Simple Code Optimization Techniques.

ALGORITHM:

1. Read the un-optimized input block.
2. Identify the types of optimization
3. Optimize the input block
4. Print the optimized input block
5. Execute the same with different set of un-optimized inputs and obtain the optimized input block.

PROGRAM:

```
#include<stdio.h>
#include<conio.h>
#include<ctype.h>
void main()
{
   char a[25][25],u,op1='*',op2='+',op3='/',op4='-';
   int p,q,r,l,o,ch,i=1,c,k,j,count=0;
   FILE *fi,*fo;
  // clrscr();
   printf("Enter three address code");
   printf("\nEnter the ctrl-z to complete:\n");
   fi=fopen("infile.txt","w");
   while((c=getchar())!=EOF)
      fputc(c,fi);
   fclose(fi);
   printf("\n Unoptimized input block\n");
   fi=fopen("infile.txt","r");
   while((c=fgetc(fi))!=EOF)
   {
                  k=1;
                  while(c!=';'&&c!=EOF)
                  {
                        a[i][k]=c;
                        printf("%c",a[i][k]);
                        k++;
                        c=fgetc(fi);
                  }
                  printf("\n");
                  i++;
   }
   count=i;
   fclose(fi);
   i=1;
   printf("\n Optimized three address code");
   while(i<count)
```

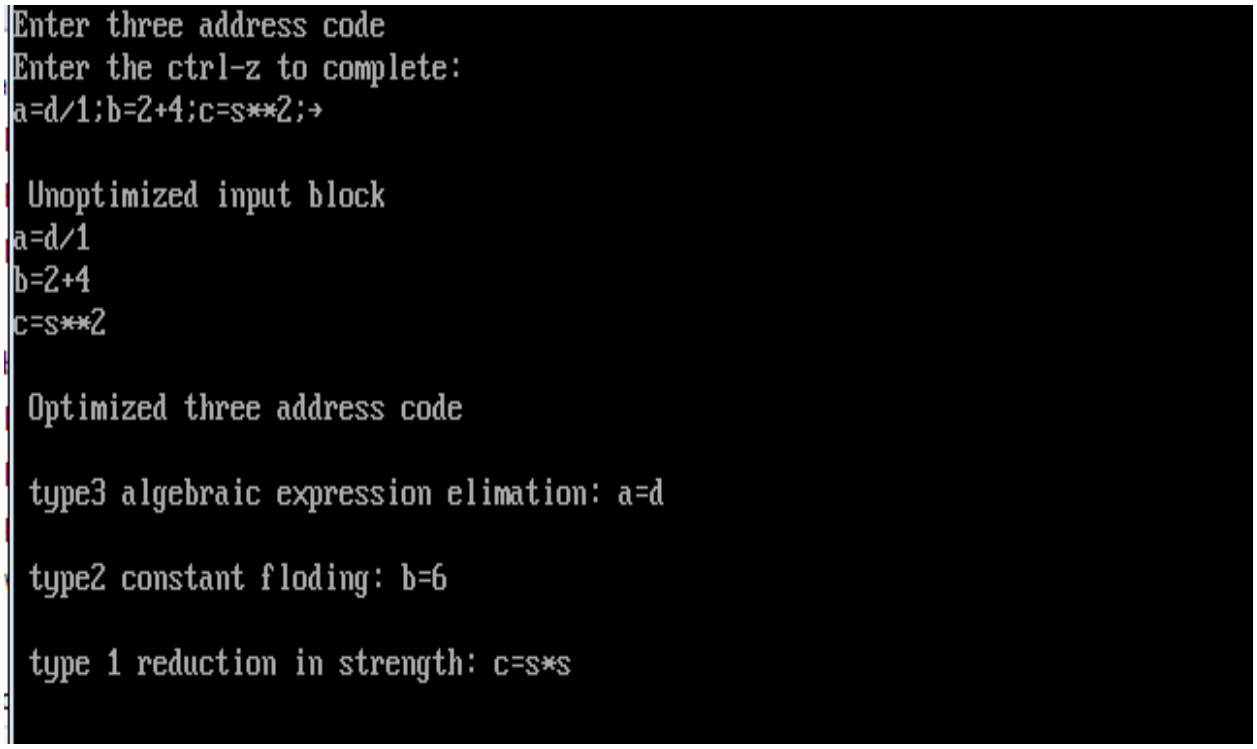
```
{
    if(strcmp(a[i][4],op1)==0&&strcmp(a[i][5],op1)==0)
    {
       printf("\n type 1 reduction in strength");
            if(strcmp(a[i][6],'2')==0)
            {
               for(j=1;j<=4;j++)
                    printf("%c",a[i][j]);
               printf("%c",a[i][3]);
            }
    }
    else if(isdigit(a[i][3])&&isdigit(a[i][5]))
    {
            printf("\n type2 constant floding");
            p=a[i][3];
            q=a[i][5];
            if(strcmp(a[i][4],op1)==0)
               r=p*q;
            if(strcmp(a[i][4],op2)==0)
               r=p+q;
            if(strcmp(a[i][4],op3)==0)
               r=p/q;
            if(strcmp(a[i][4],op4)==0)
               r=p-q;
            for(j=1;j<=2;j++)
               printf("%c",a[i][j]);
            printf("%d",r);
            printf("\n");
    }
    else if(strcmp(a[i][5],'0')==0||strcmp(a[i][5],'1')==0)
    {
       cprintf("\n type3 algebraic expression elimation");

            if((strcmp(a[i][4],op1)==0&&strcmp(a[i][5],'1')==0)||(strcmp(a[i][4],op3)==0&&strcmp(a[i][5],'
            1')==0))
      {
         for(j=1;j<=3;j++)
```

```
                printf("%c",a[i][j]);
            printf("\n");
          }

          else
            printf("\n sorry cannot optimize\n");
        }
        else
        {
          printf("\n Error input");
        }

      i++;
   }
   getch();
}
```

infile.txt

a=d/1; b=2+4; c=s**2;

OUTPUT



RESULT

Thus the C program for implementation of Code optimization was executed successfully.