VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT

on

COMPILER DESIGN

Submitted by

Dikshya Aryal (1BM21CS058)

Under the Guidance of

Prof. Sonika Sharma D

Assistant Professor, BMSCE

in partial fulfillment for the award of the degree of

BACHELOR OF ENGINEERING

COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING

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B. M. S. College of Engineering,

Bull Temple Road, Bangalore 560019

(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**COMPILER DESIGN**" carried out by **DIKSHYA ARYAL (1BM21CS058),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the academic semester November-2023 to February-2024. The Lab report has been approved as it satisfies the academic requirements in respect of a COMPILER DESIGN **(22CS5PCCPD)** work prescribed for the said degree.

Prof. Sonika Sharm D
Associate Professor

Department of CSE
BMSCE, Bengaluru

Dr. Jyothi S Nayak
Professor and Head

Department of CSE
BMSCE, Bengaluru

B. M. S. COLLEGE OF ENGINEERING

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DECLARATION

I, DIKSHYA ARYAL(1BM21CS058), student of 5th Semester, B.E, Department of Computer Science and Engineering, B. M. S. College of Engineering, Bangalore, here by declare that, this lab report entitled " **Compiler Design**" has been carried out by me under the guidance of Prof. Sonika Sharma D, Assistant Professor, Department of CSE, B. M. S. College of Engineering, Bangalore during the academic semester November-2023-February-2024.

I also declare that to the best of my knowledge and belief, the development reported here is not from part of any other report by any other students.

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CourseOutcome

CO1	Apply the fundamental concepts for the various phases of compiler design.
CO2	Analyze the syntax and seman@c concepts of a compiler.
CO3	Design various types of parsers and Address code genera@on
CO4	Implement compiler principles, methodologies using lex, yacc tools

Part-A: Implementation of Lexical Analyzer, By using C/C++/Java/Python language and using LEX tool.

Q1) Write a program to design Lexical Analyzer in C/C++/Java/Python Language (to recognize any five keywords, identifiers, numbers, operators and punctuations) CODE :

```
#include <stdbool.h>
#include <stdio.h>
#include <string.h> #include
<stdlib.h> bool
isDelimiter(char ch)
{ if (ch == ' ' || ch == '+' || ch == '-' || ch ==
'*' || ch == '/' || ch == ',' || ch == ';' || ch == '>'
|| ch == '<' || ch == '=' || ch == '(' || ch == ')' ||
ch == '[' || ch == ']' || ch == '{' || ch == '}')
return (true); return (false); } bool
isOperator(char ch)
{ if (ch == '+' || ch == '-' || ch ==
'*' || ch == '/' || ch == '>' || ch == '<'
|| ch == '=') return (true);
return (false); }  bool
validIdentifier(char* str)
{ if (str[0] == '0' || str[0] == '1' || str[0] ==  '2'
|| str[0] == '3' || str[0] == '4' || str[0] == '5' ||
str[0] == '6' || str[0] == '7' || str[0] == '8' ||
str[0] == '9' || isDelimiter(str[0]) == true)
return (false); return (true); } bool
isKeyword(char* str)
```

```
{
if (!strcmp(str, "if") || !strcmp(str, "else") ||
!strcmp(str, "while") || !strcmp(str, "do") ||
!strcmp(str, "break") ||
!strcmp(str, "continue") || !strcmp(str, "int")
|| !strcmp(str, "double") || !strcmp(str, "float")
|| !strcmp(str, "return") || !strcmp(str, "char")
|| !strcmp(str, "case") || !strcmp(str, "char")
|| !strcmp(str, "sizeof") || !strcmp(str, "long")
|| !strcmp(str, "short") || !strcmp(str, "typedef")
|| !strcmp(str, "switch") || !strcmp(str, "unsigned")
|| !strcmp(str, "void") || !strcmp(str, "static") ||
!strcmp(str, "struct") || !strcmp(str, "goto"))
return (true); return (false); } bool
isInteger(char* str) { int i, len = strlen(str);

if (len == 0) return
(false);
for (i = 0; i < len; i++) { if (str[i] != '0' && str[i]
!= '1' && str[i] != '2'
&& str[i] != '3' && str[i] != '4' && str[i] != '5'
&& str[i] != '6' && str[i] != '7' && str[i] != '8'
&& str[i] != '9' || (str[i] == '-' && i > 0)) return
(false);
}
return (true); } bool isRealNumber(char*
str)
```

```
{ int i, len = strlen(str);
bool hasDecimal = false;
if (len == 0) return
(false);
for (i = 0; i < len; i++) { if (str[i] != '0' && str[i]
!= '1' && str[i] != '2'
&& str[i] != '3' && str[i] != '4' && str[i] != '5'
&& str[i] != '6' && str[i] != '7' && str[i] != '8'
&& str[i] != '9' && str[i] != '.' ||
(str[i] == '-' && i > 0)) return
(false); if
(str[i] == '.')
hasDecimal = true; }
return
(hasDecimal); }
char* subString(char* str, int left, int right)
{ int i; char* subStr
=
(char*)malloc( sizeof(char) * (right
- left + 2));

for (i = left; i <= right; i++)
subStr[i - left] = str[i]; subStr[right
- left + 1] = '\0'; return (subStr); }
void parse(char* str) { int left = 0,
right = 0; int len = strlen(str);
```

```
while (right <= len && left <= right) { if
(isDelimiter(str[right]) == false)
right++;

if (isDelimiter(str[right]) == true && left == right) { if
(isOperator(str[right]) == true) printf("'%c' IS AN OPERATOR\n",
str[right]);

right++; left
= right;
} else if (isDelimiter(str[right]) == true && left !=
right  || (right == len && left != right)) { char* subStr
= subString(str, left, right - 1);

if (isKeyword(subStr) == true) printf("'%s'
IS A KEYWORD\n", subStr);
else if (isInteger(subStr) == true) printf("'%s'
IS AN INTEGER\n", subStr);

//else if (isRealNumber(subStr) == true)
//printf("'%s' IS A REAL NUMBER\n", subStr);
else if (validIdentifier(subStr) == true &&
isDelimiter(str[right - 1]) == false) printf("'%s' IS A
VALID IDENTIFIER\n", subStr);
```

```
else if (validIdentifier(subStr) == false && isDelimiter(str[right
- 1]) == false) printf("'%s' IS NOT A VALID IDENTIFIER\n",
subStr);
left = right;
} } return;
} int
main()
{
// maximum length of string is 100 here
char str[100] = "int a = b + 1c; "; parse(str);
// calling the parse function


return (0); }
```

OUTPUT:

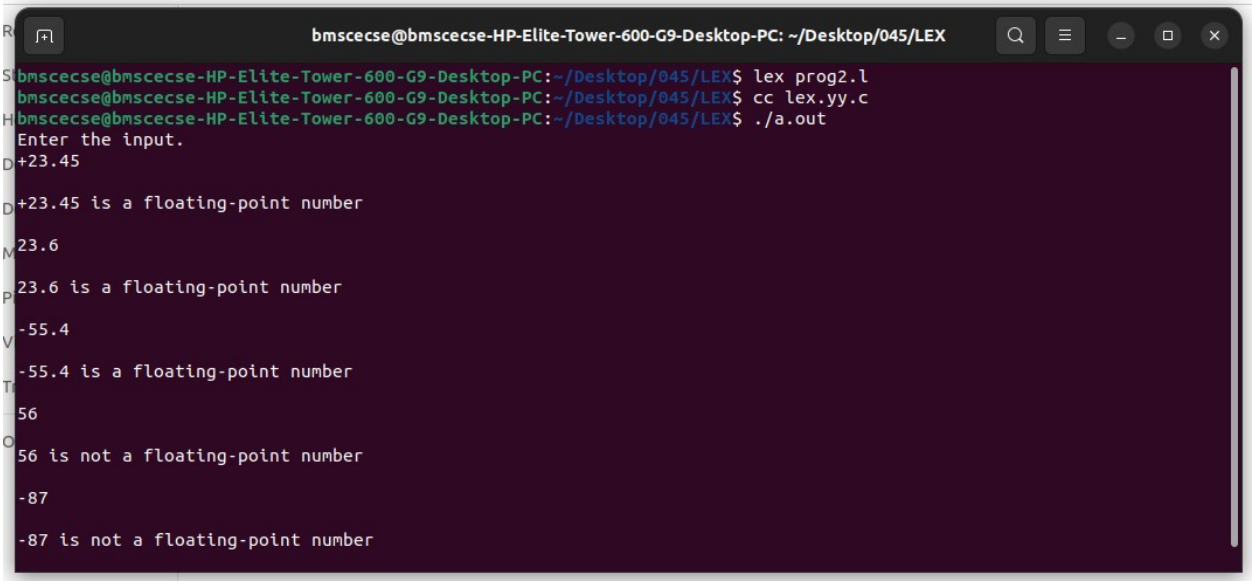
```
Output
/tmp/zuaF3np2Ol.o
Input:int a = b + 1c;
'int' IS A KEYWORD
'a' IS A VALID IDENTIFIER
'=' IS AN OPERATOR
'b' IS A VALID IDENTIFIER
'+' IS AN OPERATOR
'1c' IS NOT A VALID IDENTIFIER
```

Q2)Write a program in LEX to recognize Floating Point Numbers.

CODE:

```
%{
#include<stdio.h>
%}
%%
[+|-]?[0-9]*[.][0-9]* {printf("%s is a floating-point number\n",yytext);}
.* {printf("%s is not a floating-point number\n",yytext);}
%%
int yywrap()
{
} int main() { printf("Enter
the string : "); yylex(); return
0;
}
```

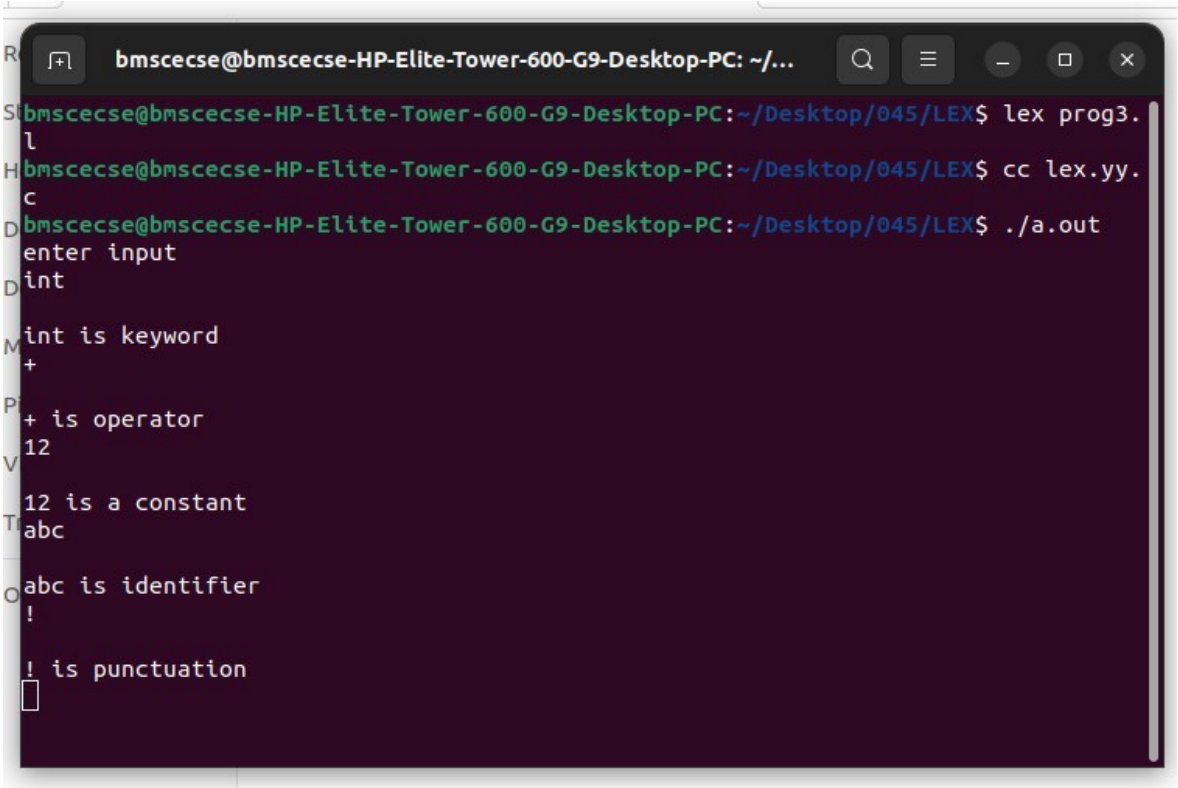
OUTPUT:



Q3) Write a program in LEX to recognize different tokens: Keywords, Identifiers, Constants, Operators and Punctuation symbols.

CODE:

```
%{
#include<stdio.h>
%} %%
int|char|float|else|for|void|mainz\while {printf("%s is keyword\n",yytext);}
[a-zA-Z_][a-zA-Z0-9_]* {printf("%s is identifier\n",yytext);}
[0-9]* {printf("%s is a constant\n",yytext);}
[+*^%/<>&=()|]* {printf("%s is operator\n",yytext);}
[?|,.'";:]* {printf("%s is punctuation\n",yytext);}
%%
int yywrap()
{ } int main() { printf("Enter
input\n"); yylex(); return 0;
```

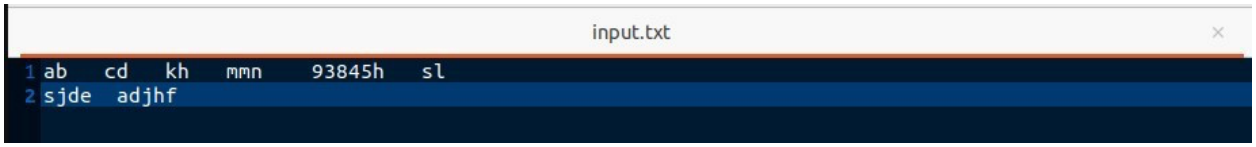


Q4) Write a LEX program that copies a file, replacing each nonempty sequence of white spaces by a single blank.

CODE:

```
/*Definition Section*/

%{

#include<stdio.h> %} %%

[\t" "]+ fprintf(yyout," ");

.|\n fprintf(yyout,"%s",yy

text); %%


int yywrap() { return 1; } int main(void)



{ yyin=fopen("input.txt","r");

yyout=fopen("output.txt","w");

yylex(); return 0; }
```

OUTPUT:



Q5) Write a LEX program to recognize the following tokens over the alphabets {0,1,..,9} a)

The set of all string ending in 00.

b) The set of all strings with three consecutive 222's.

c) The set of all string such that every block of five consecutive symbols contains at least two 5's.

d) The set of all strings beginning with a 1 which, interpreted as the binary representation of an integer, is congruent to zero modulo 5.

e) The set of all strings such that the 10th symbol from the right end is 1.

f) The set of all four digits numbers whose sum is 9

g) The set of all four digital numbers, whose individual digits are in ascending order from left to right.

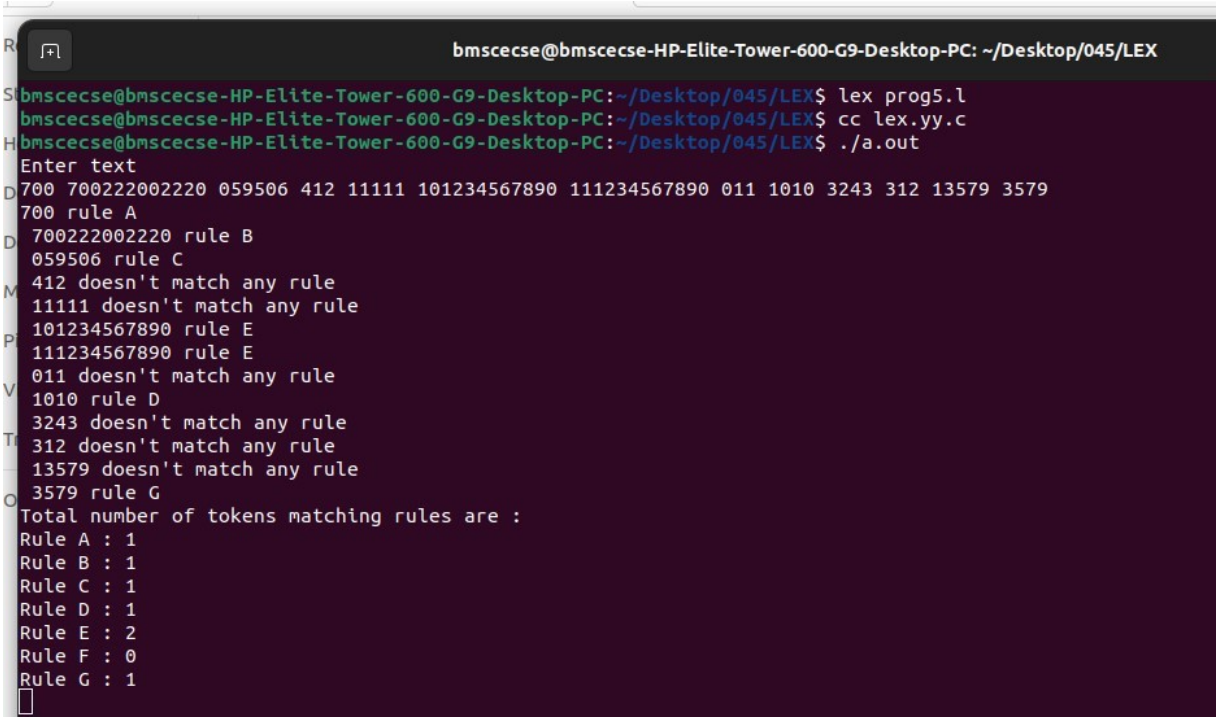
CODE:

```
{ int
c1=0,c2=0,c3=0,c4=0,c5=0,c6=0,c7=0;
%}
d[0-9]
%%
({d})*00 { c1++; printf("%s rule
A\n",yytext); }

({d})*222({d})* { c2++; printf("%s
 rule B \n",yytext);
}


(1(0)*(11|01)(01*01|00*10(0)*(11|1))*0)(1|10(0)*(11|01)(01*01|00*10(0)*(11|1))*10)* { c4++;
printf("%s rule D \n",yytext);
}
```

```
({d})*1{d}{9} { c5++; printf("%s rule
E \n",yytext);

}
{d}{4} { int sum=0,i; for(i=0;i<4;i++) { sum=sum+yytext[i]-
 48; } if(sum==9) { c6++; printf("%s rule F \n",yytext);
} else
{ sum=1;

  for(i=0;i<3;i++){
   if(yytext[i]>yytext[i+1]) { sum=0; break;
   }
  } if(sum==1) { c7++; printf("%s
  rule G\n",yytext);
  } else { printf("%s doesn't match any rule\n",yytext);
  }
}
}
({d})* { int i,c=0; if(yyleng<5) { printf("%s doesn't match
any rule\n",yytext); } else { for(i=0;i<5;i++) {
if(yytext[i]=='5') { c++; } } if(c>=2) {

for(;i<yyleng;i++)

{

if(yytext[i-5]=='5') { c--; } if(yytext[i]=='5')
{ c++;
```

```
}
if(c<2) { printf("%s doesn't match any rule\n",yytext); break; }
}
if(yyleng==i) { printf("%s rule C\n",yytext); c3++; }
} else { printf("%s doesn't match any
rule\n",yytext);
}
}
} \n { printf("Total number of tokens matching rules are  :
\n"); printf("Rule A : %d \n",c1); printf("Rule B : %d \n",c2);
printf("Rule C : %d \n",c3); printf("Rule D : %d \n",c4);
printf("Rule E : %d \n",c5); printf("Rule F :
%d \n",c6); printf("Rule G : %d \n",c7);
}
%%
int yywrap()
{ } int main() {
printf("Enter text\n");  yylex();
return 0;
```

Output:


bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC: ~/Desktop/045/LEX
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045/LEX$ lex prog5.l
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045/LEX$ cc lex.yy.c
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045/LEX$ ./a.out
Enter text
700 700222002220 059506 412 11111 101234567890 111234567890 011 1010 3243 312 13579 3579
700 rule A
700222002220 rule B
059506 rule C
412 doesn't match any rule
11111 doesn't match any rule
101234567890 rule E
111234567890 rule E
011 doesn't match any rule
1010 rule D
3243 doesn't match any rule
312 doesn't match any rule
13579 doesn't match any rule
3579 rule G
Total number of tokens matching rules are :
Rule A : 1
Rule B : 1
Rule C : 1
Rule D : 1
Rule E : 2
Rule F : 0
Rule G : 1

Part Recursive Predictive Parser

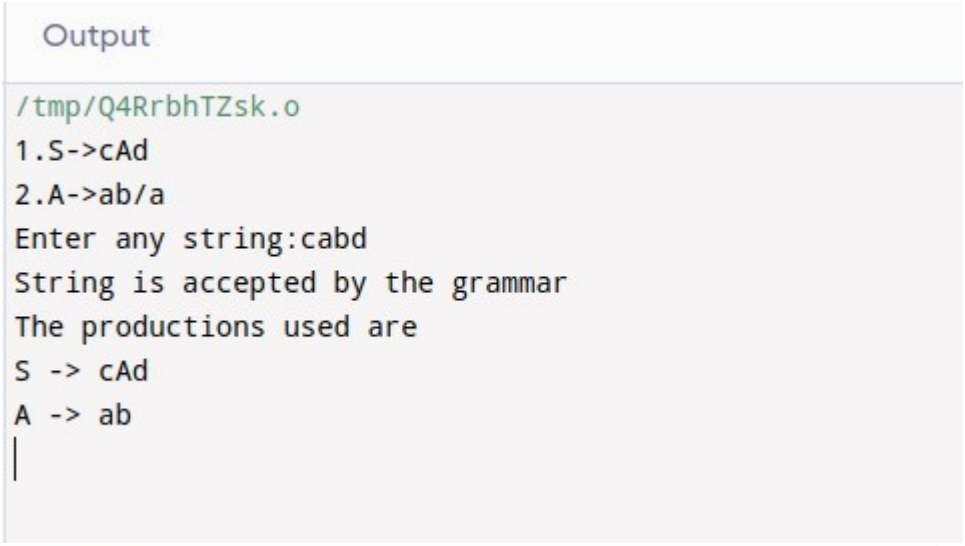
Q1) Write a program to implement (a) Recursive Descent Parsing with back tracking (Brute Force Method). S→ cAd , A →ab /a CODE:

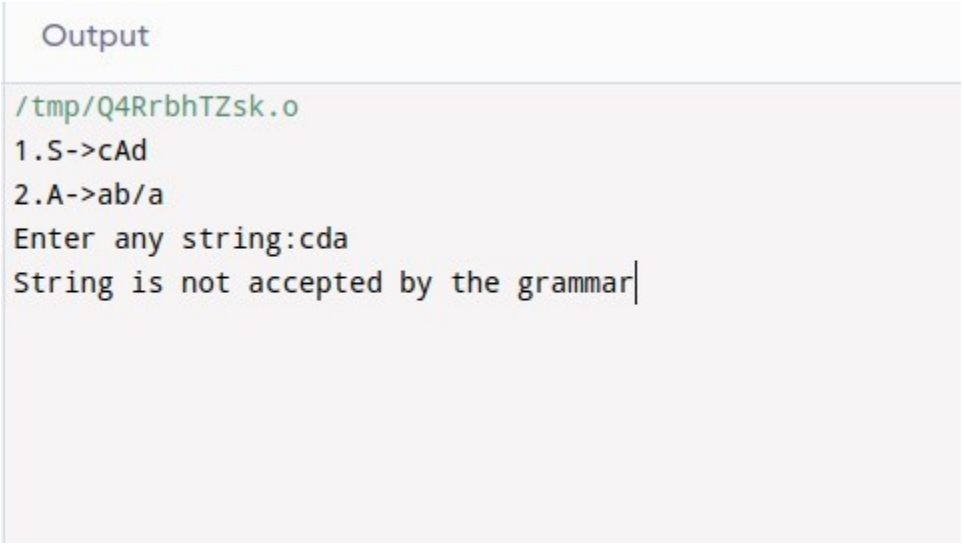
```
#include<stdio.h>
#include<string.h>
int A(); void parse();
char str[15]; int
isave,curr_ptr=0; int
c=1;

int main(void)
{ printf("1.S->cAd\n2.A->ab/a\n"); //printf("this is parser
   for the above grammar:\n"); printf("Enter any
   string:"); scanf("%s",str); while(curr_ptr<strlen(str))
   {
      //S has only one immediate derivation which is cAd
      //match with c if
      (str[curr_ptr]=='c')
      { curr_ptr++; //call function to match A if (A())
         //checking the productions of A->ab/a
         { curr_ptr++; //match d if (str[curr_ptr]=='d' &&
            str[curr_ptr+1]=='\0')
            {
               //success printf("String is accepted by the
         grammar\n"); parse(); return 1; } else break; } else
         break;
      } else break;
   }
```

```
    //incase any of them fail to match return negatively.
printf("String is not accepted by the grammar"); return
0; }

int A()
//sub function A()
{
    //this function matches all terminal strings generated by the variable

    isave=curr_ptr;
    //match with a and advance and match with b. If successful return

    if (str[curr_ptr]=='a')
    { curr_ptr++;
       if(str[curr_ptr]=='b'
       )
       { c=1; return
          1;
       }
    } curr_ptr=isave; //return to start
    //check if a is matched and return accordingly. if(str[curr_ptr]=='a')
    { c=2; return 1; }  else
    return 0; } void parse(){
printf("The productions used are \n"); printf("S
-> cAd\n"); if(c==1) printf("A
-> ab\n"); else printf("A -> a\n");
```

}

OUTPUT:


Output
/tmp/Q4RrbhTZsk.o
1.S->cAd
2.A->ab/a
Enter any string:cabd
String is accepted by the grammar
The productions used are
S -> cAd
A -> ab


Output
/tmp/Q4RrbhTZsk.o
1.S->cAd
2.A->ab/a
Enter any string:cda
String is not accepted by the grammar

PART-C :Syntax Directed Translation using YACC tool

Q1) Design a suitable grammar for evaluation of arithmetic expression having + and – operators. + has least priority and it is left associative - has higher priority and is right associative prog.l

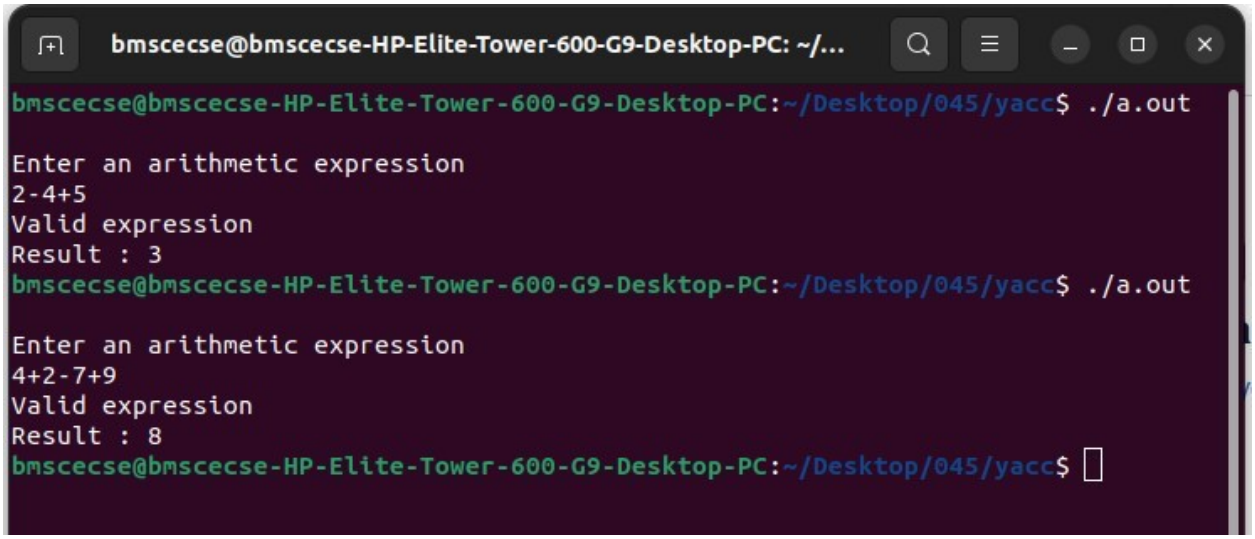
```
%{
#include "y.tab.h"
%}

%%
[0-9]+ {yylval = atoi(yytext); return
NUM;}
[\t] ;
\n return 0;
. return yytext[0];
%%
int yywrap()
{
}
```

prog.y

```
%{
        /* Definition section */
#include <stdio.h> %}

%token NUM
%left '+'
%right '-'
```

```
/* Rule Section */
%%
expr:e {printf("Valid expression\n");
printf("Result : %d\n",$$); return 0;}
e: e'+'e {$$=$1+$3;} | e'-'e {$$=$1-
$3;}
| NUM {$$=$1;}
;
%%

int main(){ printf("\nEnter an arithmetic expression\n"); yyparse();
return 0; }

int yyerror(){ printf("\nInvalid expression\n");
        return 0;
}
```

OUTPUT:



Q2) Use YACC to implement, evaluator for arithmetic expressions (Desktop calculator) .

prog.l

```
%{
/* Definition section */
#include<stdio.h>
#include "y.tab.h" extern
int yylval;
%}

/* Rule Section */
%%
[0-9]+ {
                yylval=atoi(yytext); return
                NUMBER;
        }
[\t] ;

[\n] return 0;
. return yytext[0];

%%

int yywrap() {
return 1; }
```

prog.y

```
%{
/* Definition section */
#include<stdio.h> int flag=0;
```

```
%}

%token NUMBER

%right '^'
%left '+' '-'

%left '*' '/' '%'
%left '(' ')'

/* Rule Section */
%%

expr:E {printf("Valid expression\n"); printf("Result
: %d\n",$$); return
0;}
E:E'+'E {$$=$1+$3;}
|E'-'E {$$=$1-$3;}

|E'*'E {$$=$1*$3;}

|E'/'E {$$=$1/$3;}

|E'%'E {$$=$1%$3;}

|E'^'E {$$=$1^$3;}
```

```
|'('E')' {$$=$2;}

| NUMBER {$$=$1;}

;

%%
//driver code void main() { printf("\nEnter Any Arithmetic
Expression:\n");

yyparse(); if(flag==0) printf("\nEntered arithmetic expression
is Valid\n\n");  }

void yyerror() { printf("\nEntered arithmetic expression is
Invalid\n\n"); flag=1;

}
```

OUTPUT:

Q3) Use YACC to generate Syntax tree for a given expression. prog.l

```
%{
#include "y.tab.h" extern int
yylval;
%}
%%
[0-9]+ { yylval = atoi(yytext); return digit;
}

[\t] ;
[\n] return 0;
. return yytext[0];
%%
int yywrap(){ }
```

prog.y

```
%{
#include
<math.h>
#include<ctype.h>
#include<stdio.h>
#include<stdlib.h>
#include<string.h> struct
tree_node { char val[10]; int lc;
int rc; }; int ind; struct tree_node
syn_tree[100]; void
```

```
my_print_tree(int cur_ind); int
mknode(int lc,int rc,char val[10]);
%}
%token digit
%right '^'
%left '+' '-'
%left '*' '/' '%'
%%
S:E { my_print_tree($1); }
;
E:E'+'T { $$= mknode($1,$3,"+"); ; }
|T { $$=$1; }
;
E:E'-'T { $$= mknode($1,$3,"-"); ; }
|T { $$=$1; }
;
T:T'*'F { $$= mknode($1,$3,"*"); ; }
|F {$$=$1 ; }
;
T:T'/'F { $$= mknode($1,$3,"/"); ; }
|F {$$=$1 ; }
;
F:'('E')' { $$=$2; }
|digit {char buf[10]; sprintf(buf,"%d", yylval); $$ = mknode(-1,-1,buf);} %% int
main() { ind=0;
```

```
printf("Enter an expression\n");
yyparse(); return 0; } int yyerror()
{ printf("NITW Error\n");
} int mknode(int lc,int rc,char val[10])
{ strcpy(syn_tree[ind].val,val);
syn_tree[ind].lc = lc; syn_tree[ind].rc
= rc; ind++; return ind-1;
}
/*my_print_tree function to print the syntax tree in DLR fashion*/ void my_print_tree(int
cur_ind)
{ if(cur_ind==-1) return; if(syn_tree[cur_ind].lc==-
1&&syn_tree[cur_ind].rc==-1) printf("Digit Node -> Index : %d, Value :
%s\n",cur_ind,syn_tree[cur_ind].val); else printf("Operator Node -> Index : %d, Value :
%s, Left Child Index : %d,Right Child Index :
%d\n",cur_ind,syn_tree[cur_ind].val, syn_tree[cur_ind].lc,syn_tree[cur_ind].rc);
my_print_tree(syn_tree[cur_ind].lc); my_print_tree(syn_tree[cur_ind].rc); }
```

OUTPUT:

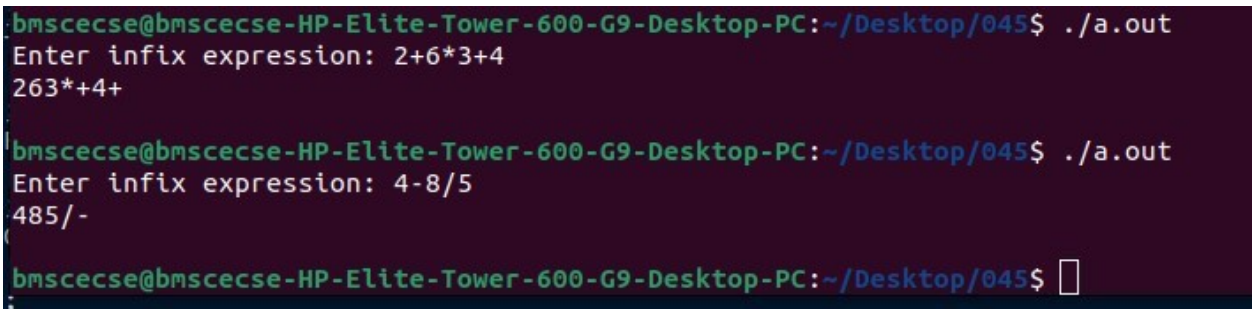
Q4) Use YACC to convert: Infix expression to Postfix expression.

prog.l

```
%{
#include "y.tab.h" extern int
yylval;
%}
%%
[0-9]+ { yylval=atoi(yytext); return digit;}
[\t] ;
[\n] return 0;
. return yytext[0];
%%
int yywrap()
{ } prog.y
%{
#include <ctype.h>
#include<stdio.h>
#include<stdlib.h>
%}
%token digit
%right '^'
%left '+' '-'
%left '*' '/'

%%
S: E {printf("\n\n");}
;
```

```
E: E '+' T { printf ("+");}
| T
;
E: E '-' T { printf ("-");}
| T
;
T: T '*' F { printf("*");}
| F
;
T: T '/' F { printf("/");}
| F
;
F: F '^' G { printf("^");}
| G
;
G: '(' E ')'
| digit {printf("%d", $1);}
;
%%
int main() { printf("Enter infix  expression:
"); yyparse(); } yyerror()
{
printf("Error"); }
```

OUTPUT:

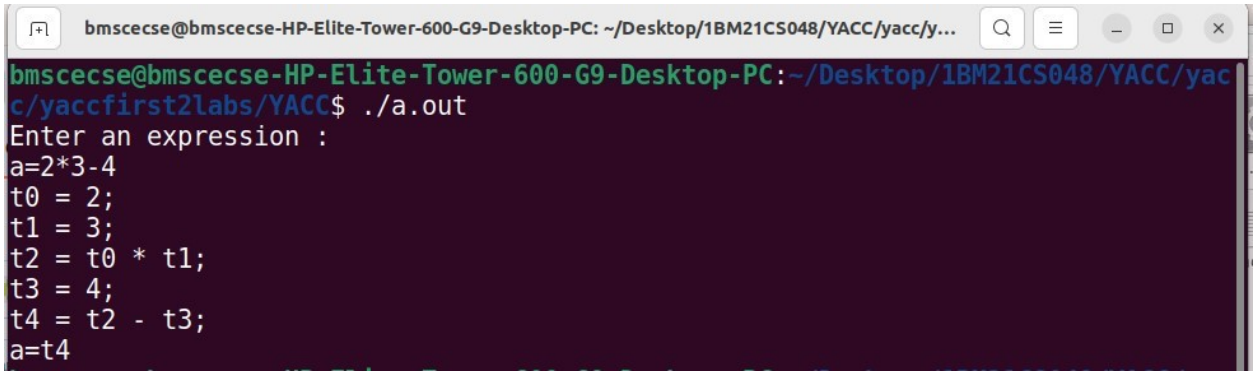

bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$ ./a.out
Enter infix expression: 2+6*3+4
263*+4+
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$ ./a.out
Enter infix expression: 4-8/5
485/-
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$

Q5) Use YACC to generate 3-Address code for a given expression.

```
prog.l d [09]+
a [azA-Z]+
%{
#include<stdio.h>
#include<stdlib.h>
#include"y.tab.h"
extern int yylval; extern
char iden[20];
%}
%%
{d} { yylval=atoi(yytext); return digit; }
{a} { strcpy(iden,yytext); yylval=1; return id;}
[ \t] {;}
\n return 0;
. return yytext[0];
%%
int yywrap() {
} prog.y
%{
#include <math.h>
#include<ctype.h>
#include<stdio.h>
int var_cnt=0; char
iden[20];
%}
%token id
%token digit
```

```
%%
S:id '=' E { printf("%s=t%d\n",iden,var_cnt-1); } E:E '+' T { $$=var_cnt; var_cnt++; printf("t%d =
t%d + t%d;\n", $$, $1, $3 );
}
|E '-' T { $$=var_cnt; var_cnt++; printf("t%d = t%d - t%d;\n", $$, $1, $3 ); }
|T { $$=$1; }
;
T:T '*' F { $$=var_cnt; var_cnt++; printf("t%d = t%d * t%d;\n", $$, $1, $3 ); }
|T '/' F { $$=var_cnt; var_cnt++; printf("t%d = t%d / t%d;\n", $$, $1, $3 ); }
|F {$$=$1 ; }
F:P '^' F { $$=var_cnt; var_cnt++; printf("t%d = t%d ^ t%d;\n", $$, $1, $3 );}
| P { $$ = $1;}
;
P: '(' E ')' { $$=$2; }
|digit { $$=var_cnt; var_cnt++; printf("t%d = %d;\n",$$,$1); }
;
%%
int main() { var_cnt=0;
printf("Enter an expression : \n"); yyparse(); return
0; } yyerror()
{ printf("error");
}
```

OUTPUT:


bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC: ~/Desktop/1BM21CS048/YACC/yacc/y...
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/1BM21CS048/YACC/yac
c/yaccfirst2labs/YACC$ ./a.out
Enter an expression :
a=2*3-4
t0 = 2;
t1 = 3;
t2 = t0 * t1;
t3 = 4;
t4 = t2 - t3;
a=t4