VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
on

COMPILER DESIGN

Submitted by

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in partial fulfilment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING

B.M.S. COLLEGE OF ENGINEERING
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**COMPILER DESIGN**" carried out by **ARYAN RAUNIYAR (1BM21CS034),** who is bonafide student of **B.M.S. College of Engineering.** It is in partial fulfilment 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.

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DECLARATION

I, **ARYAN RAUNIYAR (1BM21CS034)**, 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. Sunayana S, 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 semantic concepts of a compiler.
CO3	Design various types of parsers and Address code generation
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()
{
char str[100] = "int a = b + 1c; "; parse(str);
return (0);


}
```

OUTPUT:

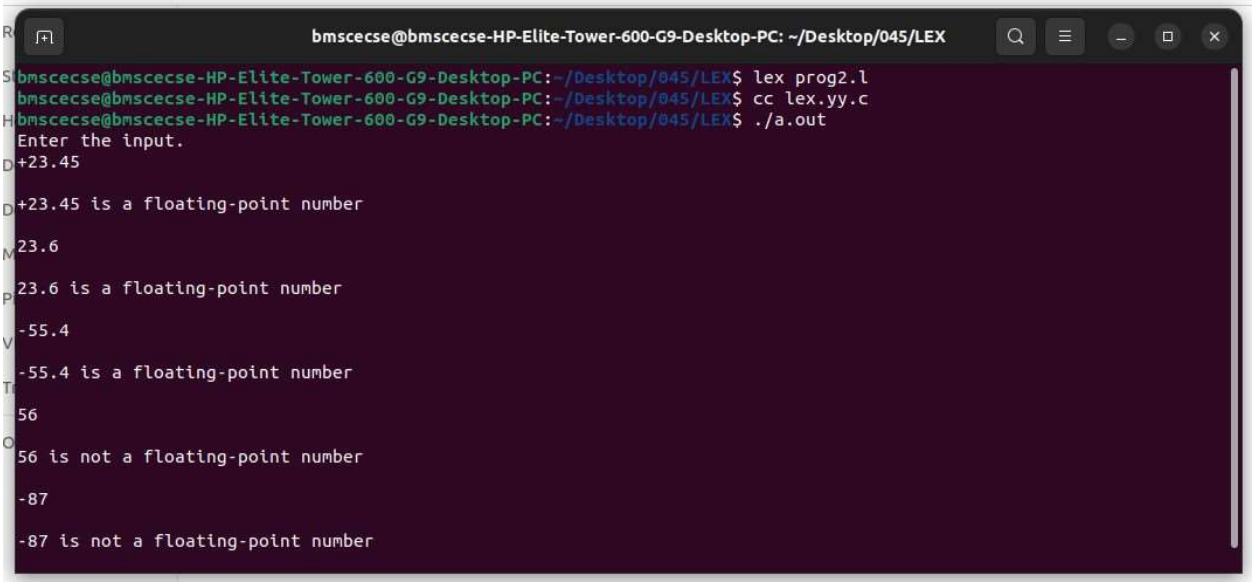
```
Output
/tmp/zuaF3np2Ol.o
Input:int a = b + 1c;
'int' IS A KEYWORD
'a' IS A VALID IDENTIFIER
'=' IS AN OPERATOR
'b' IS A VALID IDENTIFIER
'+' IS AN OPERATOR
'1c' IS NOT A VALID IDENTIFIER
```

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:

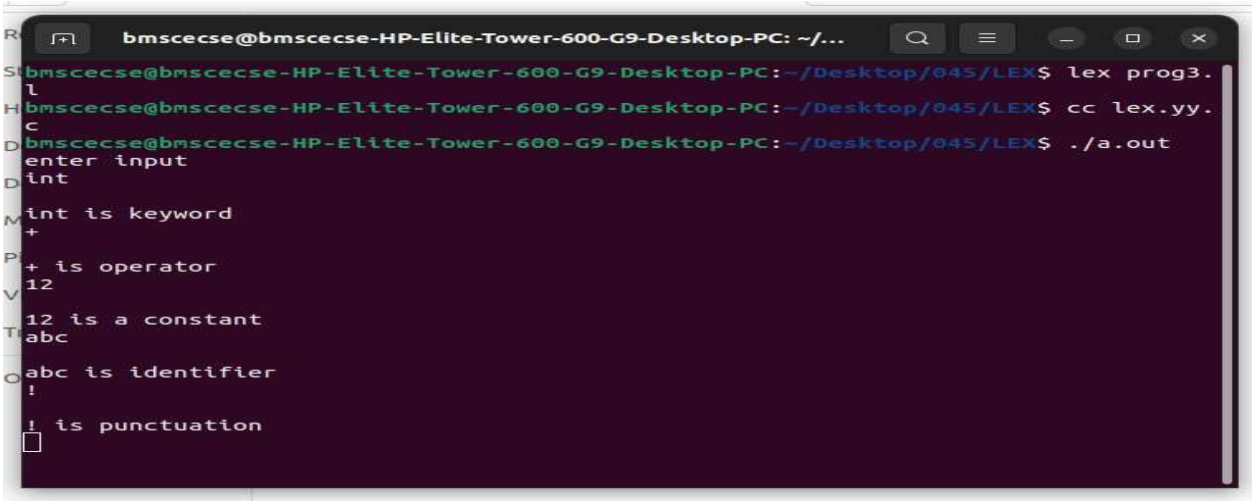


Q3) Write a program in LEX to recognize different tokens: Keywords, Identifiers, Constants, Operators and Punctuation symbols.

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;
}
```

OUTPUT:

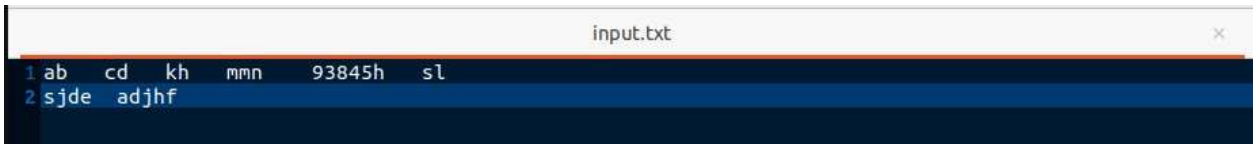


Q4) Write a LEX program that copies a file, replacing each nonempty sequence of white spaces by a single blank.

CODE:

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

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

.|\n fprintf(yyout,"%s",yytext);
%%

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:

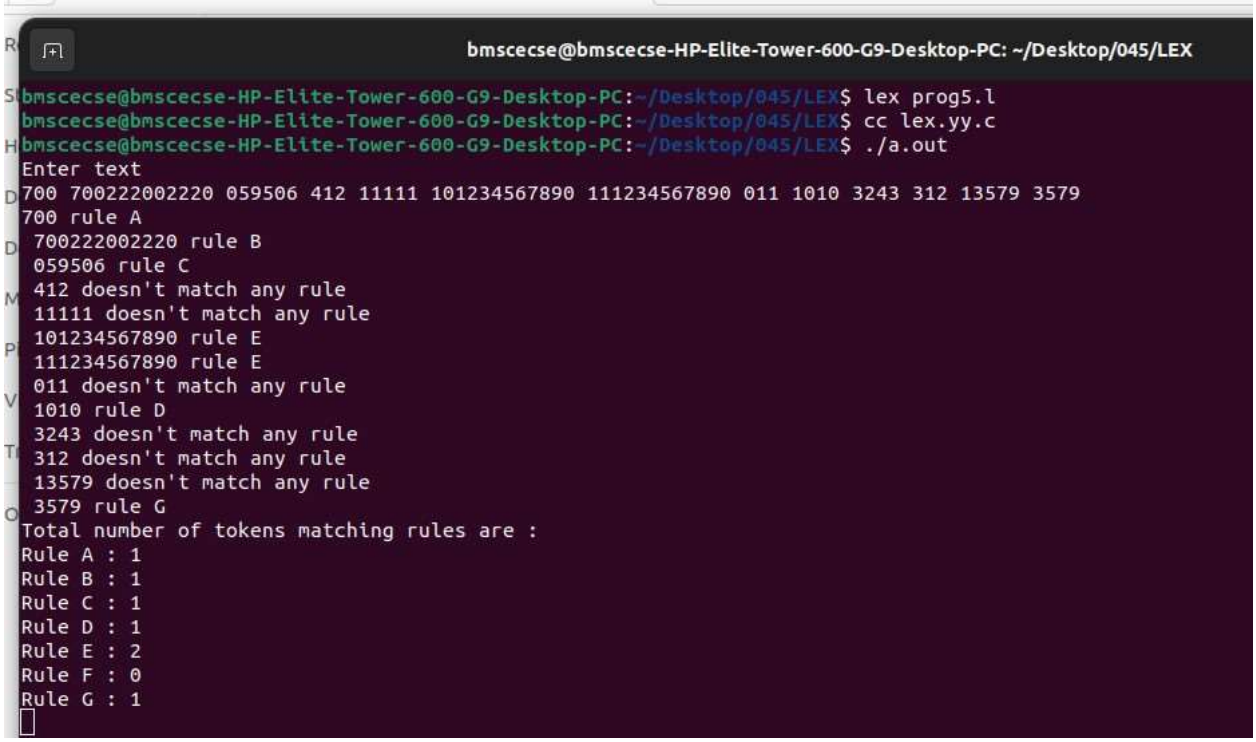
```
{ int
c1=0,c2=0,c3=0,c4=0,c5=0,c6=0,c7=0;
%}
```

```
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:



Part-B: Implementation of Parsers (Syntax Analyzers) Using C/C++/Java/Python language)

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

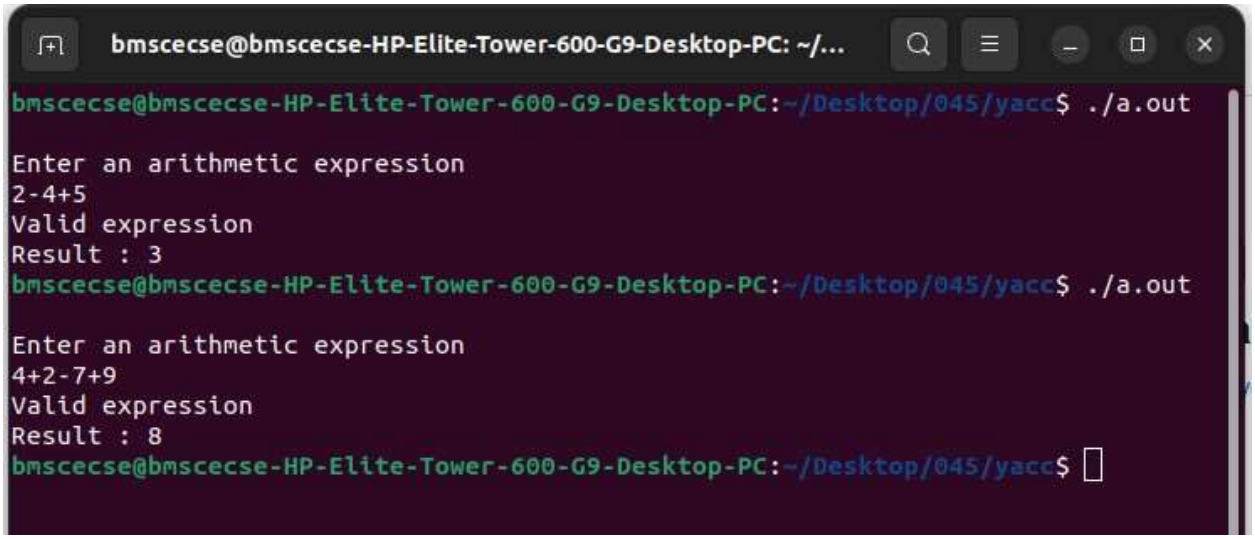
Q1) Design a suitable grammar for evaluation of arithmetic expression having + and – operators. + has least priority and it is left associative - has higher priority and is right associative prog.l

```
%{

#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:

```
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$ ./a.out
Enter an expression
2+3*5
Operator Node -> Index : 4, Value : +, Left Child Index : 0,Right Child Index : 3
Digit Node -> Index : 0, Value : 2
Operator Node -> Index : 3, Value : *, Left Child Index : 1,Right Child Index : 2
Digit Node -> Index : 1, Value : 3
Digit Node -> Index : 2, Value : 5
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$ ./a.out
Enter an expression
2-3
Operator Node -> Index : 2, Value : -, Left Child Index : 0,Right Child Index : 1
Digit Node -> Index : 0, Value : 2
Digit Node -> Index : 1, Value : 3
bmscecse@bmscecse-HP-Elite-Tower-600-G9-Desktop-PC:~/Desktop/045$
```

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

prog.l

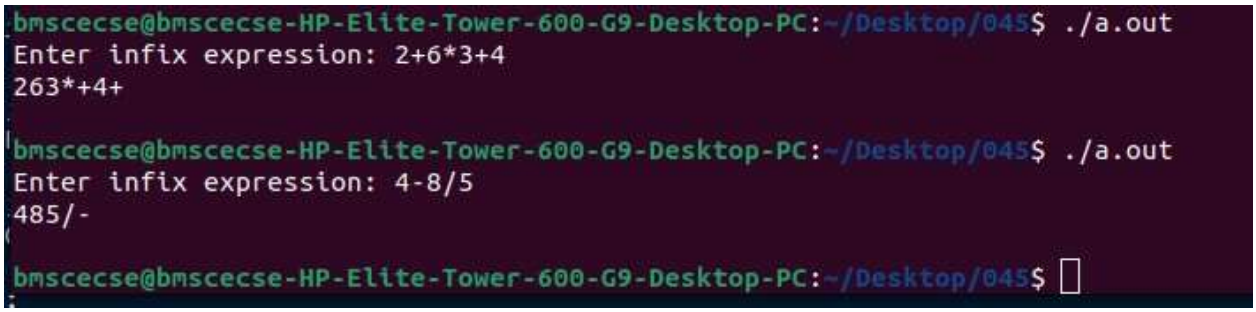
```
%{
#include "y.tab.h"
extern int yylval;
%}
%%
[0-9]+ { yylval=atoi(yytext); return digit;}
[\t] ;
[\n] return 0;
. return yytext[0];
%%
int yywrap()
{
}
```

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:



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

```
prog.l d [0-
9]+ a [a-
zA-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: