FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

B. E. (COMPUTER SCIENCE AND ENGINEERING)

VI Semester

22CSCP607 _ Compiler Design LabM

LAB MANUAL

Staff Incharge:

Dr. A. Geetha

CONTENTS

Annamalai University
Department of Computer Science and Engineering

VISION

To provide a congenial ambience for individuals to develop and blossom as academically superior, socially conscious and nationally responsible citizens.

MISSION

- Impart high quality computer knowledge to the students through a dynamic scholastic environment wherein they learn to develop technical, communication and leadership skills to bloom as a versatile professional.

- Develop life-long learning ability that allows them to be adaptive and responsive to the changes in career, society, technology, and environment.

- Build student community with high ethical standards to undertake innovative research and development in thrust areas of national and international needs.

- Expose the students to the emerging technological advancements for meeting the demands of the industry.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO	PEO Statements
PEO1	To prepare the graduates with the potential to get employed in the right role and/or become entrepreneurs to contribute to the society.
PEO2	To provide the graduates with the requisite knowledge to pursue higher education and carry out research in the field of Computer Science.
PEO3	To equip the graduates with the skills required to stay motivated and adapt to the dynamically changing world so as to remain successful in their career.
PEO4	To train the graduates to communicate effectively, work collaboratively and exhibit high levels of professionalism and ethical responsibility.

PROGRAM OUTCOMES (POs)

S. No.	Program Outcomes
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO3	**Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11	**Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

S.no	Program Specific Outcomes
PSO1	Acquire the ability to understand basic sciences, humanity sciences, basic engineering sciences and fundamental core courses in Computer Science and Engineering to realize and appreciate real life problems in diverse fields for proficient design of computer based systems of varying complexity.
PSO2	Learn specialized courses in Computer Science and Engineering to build up the aptitude for applying typical practices and approaches to deliver quality products intended for business and industry requirements.
PSO3	Apply technical and programming skills in Computer Science and Engineering essential for employing current techniques in software development crucial in industries, to create pioneering career paths for pursuing higher studies, research and to be an entrepreneur.

Rubrics for Laboratory Examination (Internal/External)

(Internal: Two tests - 15 marks each, **External:** Two questions - 25 marks each)

Rubric	Poor Up to (1/2)	Average Up to (2/4)	Good Up to (3/6)	Excellent Up to (5/8*)
<u>Syntax and Logic</u> **Ability to understand, specify the data structures appropriate for the problem domain**	Program does not compile with typographical errors and incorrect logic leading to infinite loops.	Program compiles that signals major syntactic errors and logic shows severe errors.	Program compiles with minor syntactic errors and logic is mostly correct with occasional errors.	Program compiles with evidence of good syntactic understanding of the syntax and logic used.
<u>Modularity</u> **Ability to decompose a problem into coherent and reusable functions, files, classes, or objects (as appropriate for the programming language and platform).**	Program is one big Function or is decomposed in ways that make little/no sense.	Program is decomposed into units of appropriate size, but they lack coherence or reusability. Program contains unnecessary repetition.	Program is decomposed into coherent units, but may still contain some unnecessary repetition.	Program is decomposed into coherent and reusable units, and unnecessary repetition are eliminated.
<u>Clarity and Completeness</u> **Ability to code formulae and algorithms that produce appropriate results. Ability to apply rigorous test case analysis to the problem domain.**	Program does not produce appropriate results for most inputs. Program shows little/no ability to apply different test cases.	Program approaches appropriate results for most inputs, but contain some miscalculations. Program shows evidence of test case analysis, but missing significant test cases or istaken some test cases.	Program produces appropriate results for most inputs. Program shows evidence of test case analysis that is mostly complete, but missed to handle all possible test cases.	Program produces appropriate results for all inputs tested. Program shows evidence of excellent test case analysis, and all possible cases are handled appropriately.

* 8 marks for syntax and logic, 8 marks for modularity, and 9 marks for Clarity and Completeness.

Rubric for CO3

Rubric for CO3 in Laboratory Courses				
Rubric	**Distribution of 10 Marks for CIE/SEE Evaluation Out of 40/60 Marks**			
	Up To 2.5 Marks	**Up To 5 Marks**	**Up To 7.5 Marks**	**Up To 10 marks**
Demonstrate an ability to listen and answer the viva questions related to programming skills needed for solving real-world problems in Computer Science and Engineering.	Poor listening and communication skills. Failed to relate the programming skills needed for solving the problem.	Showed better communication skill by relating the problem with the programming skills acquired but the description showed serious errors.	Demonstrated good communication skills by relating the problem with the programming skills acquired with few errors.	Demonstrated excellent communication skills by relating the problem with the programming skills acquired and have been successful in tailoring the description.

Ex No: 01 (a) **IMPLEMENTATION OF LEXICAL ANALYZER**
Date:
Aim:

To implement Lexical Analysis for given example text file using python coding.

Algorithm:

Lexical Analysis is the first phase of the compiler also known as a scanner. It converts the High-level input program into a sequence of Tokens. This sequence of tokens is sent to the parser for syntax analysis. Lexical Analysis can be implemented with the Deterministic finite Automata.

A lexical token is a sequence of characters that can be treated as a unit in the grammar of the programming languages The types of token are identifier, numbers, operators, keywords, special symbols etc.

Following are the examples of tokens:

- Keywords: Examples-for, while, if etc.
- Identifier: Examples-Variable name, function name, etc.
- Operators: Examples '+', '++', '-' etc.
- Separators: Examples ', ' ';' etc.

The algorithm for lexical analysis is as follows:

1) Read the input expression.
2) If the input is a keyword, store it as a keyword.
3) If the input is an operator, store it as operator.
4) If the input is a delimiter, store it as a delimiter.
5) Check whether input is a sequence of alphabets and/or digits then store it an identifier.
6) If the input is a sequence of digits, then store it as a number.

Source code:

```
import re
patterns = {
    'IMPORTS': r'<stdio.h>|<conio.h>|<stdlib.h>',
    'STRING': r'\".*\"',
    'KEYWORD':r'#include|if|else|for|break|int|float|void|String|char|
              double',
    'FUNCTION': r'printf|scanf|clrscr|getch',
    'FLOAT': r'\d+\.\d+',
    'INT': r'\d+',
    'OPERATOR': r'\+?\+|-|\*|/|=|==|<|>',
    'ID': r'[a-zA-Z_][a-zA-Z0-9_]*',
    'LPARAN': r'\(',
    'RPARAN': r'\)',
```

```
    'SEPARATOR': r'[;:,]',
    'LBRACE': r'\{',
    'RBRACE': r'\}'
}  def lex_anz(input):     tokens = []     regex_patt =
'|'.join(f'(?P<{tok}>{patterns[tok]})' for tok in patterns)
for match in re.finditer(regex_patt, input):
        tok_type = match.lastgroup
tok_val = match.group()
tokens.append((tok_type, tok_val))
return tokens
 with open('text.cpp', 'r') as
file:
    code = file.read()
 result =
lex_anz(code)
 for t, v in
result:
    print(f'{v} -> {t}')
```

Input:

```
#include
<stdio.h> void
main(){ int x =
3;
 if ( x < 10 ) {
       printf("hello world!");
 }
}
```

Output:

```
#include -> KEYWORD
<stdio.h> ->
IMPORTS void ->
KEYWORD      main -
> ID ( -> LPARAN
) -> RPARAN {
-> LBRACE int
```

```
-> KEYWORD x
-> ID
= -> OPERATOR
3 -> INT ; ->
SEPARATOR if
-> KEYWORD (
-> LPARAN x -
> ID < ->
OPERATOR
10 -> INT
) -> RPARAN { ->
LBRACE printf ->
FUNCTION
( -> LPARAN
"hello world!" -> STRING
) -> RPARAN
) -> RPARAN
; -> SEPARATOR
} -> RBRACE
} -> RBRACE
```

Result:

Thus, the python program to implement the Lexical Analyzer is executed successfully and verified.

Ex No: 01 (b) **IMPLEMENTATION OF LEXICAL TOOL**

Date:

Aim:

To implement Lexical Analyzer using Lexical Tool in python coding. **Algorithm:**

1) Define the set of tokens or lexemes for the programming language to be processed. These can be keywords, identifiers, operators, literals, etc. Store them in a dictionary or a list for easy access.
2) Read the input source code file to be processed.
3) Initialize a cursor or pointer to the beginning of the input source code.
4) Create a loop that iterates through the source code, character by character.
5) Implement a finite state machine (FSM) to recognize tokens. The FSM can have states representing different types of tokens, such as "keyword", "identifier", "operator", etc.
6) For each character encountered in the source code, update the FSM state based on the current character and the current state. If the current state is a final state, store the recognized token and reset the FSM state to the initial state. If the current state is not a final state and the current character does not transition to any valid state, then raise a lexical error.
7) Continue the loop until the end of the input source code is reached.
8) Output the recognized tokens along with their corresponding lexeme value or token type.

Source code:

```
   import ply.lex as
lex

tokens = (
'IMPORTS',
    'STRING',
    'KEYWORD',
    'FUNCTION',
    'FLOAT',
    'INT',
    'OPERATOR',
    'ID',
    'LPARAN',
    'RPARAN',
    'SEPARATOR',
    'LBRACE',
    'RBRACE',
)
```

```
t_IMPORTS = r'<stdio.h>|<conio.h>|<stdlib.h>' t_STRING
= r'\".*\"'
t_KEYWORD = r'\#include|if|else|for|break|int|float|void|String|char|double|
            while|do'
t_FUNCTION = r'printf|scanf|clrscr|getch'
t_FLOAT = r'\d+\.\d+' t_INT
= r'\d+'
t_OPERATOR = r'\+|-|\*|/|=|==|<|>|>=|<='
t_ID = r'[a-zA-Z_][a-zA-Z0-9_]*'
t_LPARAN = r'\(' t_RPARAN = r'\)'
t_SEPARATOR = r'[;:,]' t_LBRACE = r'\{'
t_RBRACE = r'\}' t_ignore = ' \t'
 def
t_NEWLINE(t):
    r'\n+'
    t.lexer.lineno += len(t.value)
def t_error(t):
    print("Illegal character '%s'" % t.value[0])
    t.lexer.skip(1)
lexer = lex.lex()

code = open('text.cpp').read()

lexer.input(code)
 while True:     tok =
lexer.token()     if
not tok:         break
print(tok)
```

Input:

```
#include <stdio.h>
void main(){
int x = 3;     if (
x < 10 ) {
        printf("hello world!");
    }
}
```

Output:

```
LexToken(KEYWORD,'#include',1,0)
```

```
LexToken(IMPORTS,'<stdio.h>',1,9)
LexToken(KEYWORD,'void',3,20)
LexToken(ID,'main',3,25)
LexToken(LPARAN,'(',3,29)
LexToken(RPARAN,')',3,30)
LexToken(LBRACE,'{',3,31)
LexToken(KEYWORD,'int',4,35)
LexToken(ID,'x',4,39)
LexToken(OPERATOR,'=',4,41) LexToken(INT,'3',4,43)
LexToken(SEPRATOR,';',4,44)
LexToken(KEYWORD,'if',5,48)
LexToken(LPARAN,'(',5,51)
LexToken(ID,'x',5,53)
LexToken(OPERATOR,'<',5,55)
LexToken(INT,'10',5,57)
LexToken(RPARAN,')',5,60)
LexToken(LBRACE,'{',5,62)
LexToken(FUNCTION,'printf',6,69)
LexToken(LPARAN,'(',6,75)
LexToken(STRING,'"hello world!"',6,76)
LexToken(RPARAN,')',6,90)
LexToken(SEPRATOR,';',6,91)
LexToken(RBRACE,'}',7,95)
LexToken(RBRACE,'}',8,97)
```

Results:

Thus, the python program to implement the Lexical Analyzer using Lexical Tool is executed successfully and verified

Ex No: 02 **CONVERSION OF REGULAR EXPRESSION TO NFA**

Date:

Aim:

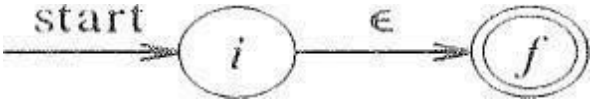
To write a python program to convert the given Regular Expression to NFA. **Algorithm:**

Thompson's Construction of an NFA from a Regular Expression:

Input: A regular expression r over the alphabet. Output: An NFA N accepting L(r)

METHOD: Begin by parsing r into its constituent subexpressions. The rules for constructing an NFA consist of the following basics rules.

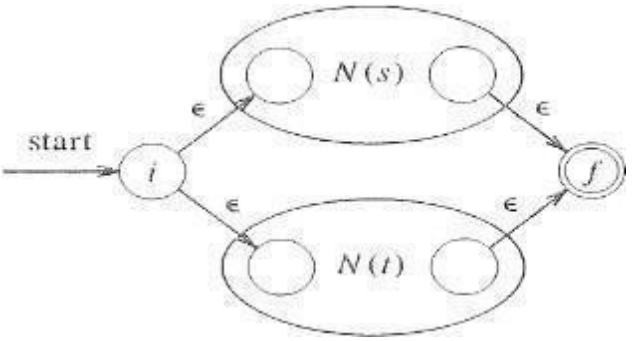
For expression e construct the NFA,



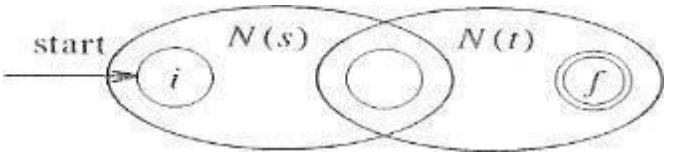
Here, i is a new state, the start state of this NFA, and f is another new state, the accepting state for the NFA.

For any subexpressions, construct the NFA,

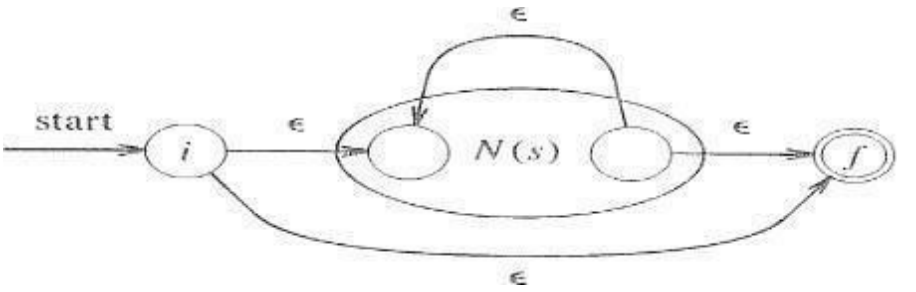
INDUCTION: Suppose N(s) and N (t) are NFA's for regular expressions s and t, respectively. a) For the regular expression s|t ,



b) For the regular expression st,



c) For the regular expression S*,



d) Finally, suppose r = (s), then L(r) = L(s), and we can use the NFA, N(s) as N(r)

Source code:

```
import re  t = 0
f = 1  def
nodret(ip):
global t, f     e
= u'\u03b5'
nodes = []
     if re.match(r'^[a-z]$',
ip):
        nodes = [
            (t, t + 1, ip)
        ]         t += 1     elif
re.match(r'^[a-z]\*$', ip):
        nodes = [
(t, t + 1, e),
            (t, t + 3, e),
            (t + 1, t + 2, ip[0]),
            (t + 2, t + 1, e),
            (t + 2, t + 3, e)
        ]
t += 3
elif
re.match(r'^[a
-z]\/[a-z]$',
ip):
        nodes = [
            (t, t + 1, e),
            (t, t + 3, e),
            (t + 1, t + 2, ip[0]),
            (t + 3, t + 4, ip[2]),
```

```
            (t + 2, t + 5, e),
            (t + 4, t + 5, e),
        ]
t += 5
else:
        print("Please enter basic expressions (linear combination of
              a, a*, a/b, a b)")
        f = 0
return nodes
 def tab_gen(v):     ips = list(set([e for e1, e2, e in
v]))     ips.sort()     a = [[[] for j in
range(len(ips))] for i in range(t)]

    # Fill the transition table
for s, d, i in v:
        a[s][ips.index(i)].append(d)
         print('State',
end="")     for x in ips:
        print(f'\t{x}', end='')
print('\n', '-' * (len(ips) * 10))
     for i in
range(t):
        print(f'{i}', end='')
for j in range(len(ips)):
            print(f'\t{a[i][j]}', end='')
print()
     print(f'State {t} is the final
state') ip = input("Enter regex (leave
space between characters): ") nodes = []
for ch in ip.split():     nodes +=
nodret(ch)
 if
f:
    tab_gen(nodes)
```

Sample Input and Output:

```
Enter regex (leave space between characters): a* b* c/d
State   a       b       c       d       ε
 ------------------------------------------------
0       []      []      []      []      [1, 3]
```

```
1       [2]     []      []      []      []
2       []      []      []      []      [1, 3]
3       []      []      []      []      [4, 6] 4
        []      [5]     []      []      []
5       []      []      []      []      [4, 6]
6       []      []      []      []      [7, 9]
7       []      []      [8]     []      []
8       []      []      []      []      [11]
9       []      []      []      [10]    []
10      []      []      []      []      [11]

State 11 is the final state
```

Results:

Thus, the python program for construction of NFA table from Regular Expression is executed successfully and tested with various samples.

Ex No: 03 **ELIMINATION OF LEFT RECURSION**

Date:

Aim:

To write a python program to implement Elimination of Left Recursion for given sample grammer.

Algorithm:

A grammar is left recursive if it has a nonterminal A such that there is a derivation A => Aα for some string. Top-down parsing methods cannot handle left-recursive grammars, so a transformation is needed to eliminate left recursion.

For each production rule `x` in the list of productions `p`:

- Initialize empty lists `alpha` and `beta`.
- Separate the productions of `x` into `alpha` (left recursive) and `beta` (non-left recursive) based on whether the production starts with the name of the non-terminal or not.
- If `alpha` is not empty:
  - Modify the right-hand side of productions in `beta` by appending the non-terminal's prime symbol.
  - Modify the right-hand side of productions in `alpha` by appending the non-terminal's prime symbol and epsilon.
  - Update the production rules for `x` with the modified `beta` productions.
  - Add new production rules for the non-terminal's prime symbol with the modified `alpha` productions to the list of productions `p`.

Source code:

```
e = '\u03b5' p = []  class Prod:
def __init__(self, name, products):
        self.name = name
self.products = products
     def
print(self):
        s = f'{self.name} -> '
for prod in self.products:
            s += f' {prod} |'
s = s.rstrip('|')
print(s)
 def trans():     for x in p:
alpha = []         beta = []         for
product in x.products:             if
x.name == product[0]:
```

```
  alpha.append(product[1:])
  else:
                  beta.append(product)
          if
  alpha:
             for i in range(len(beta)):
                 beta[i] = f"{beta[i]}{x.name}'"
  for i in range(len(alpha)):
                  alpha[i] = f"{alpha[i]}{x.name}'"
  alpha.append(e)
             x.products = beta
              p.append(Prod(f"{x.name}'",
  alpha))  n = int(input("No of productions: "))
  for i in range(n):
      ip = input(f"Production {i+1}: ")
  name, prods = ip.split(' -> ')     products
  = prods.split(' | ')
      p.append(Prod(name, products))
  print('Productions:') for x in p:
      x.print()
  print('Transforming...')
  trans()  for x in p:
      x.print()
```

Sample Input and Output:

```
No of productions: 3
  Production 1: E -> E+T | T
  Production 2: T -> T*F | F Production
  3: F -> ( E ) | id
  Productions:
  E ->  E+T | T
  T ->  T*F | F
  F ->  ( E ) | id  Transforming...
  E ->  TE'
  T ->  FT'
  F ->  ( E ) | id
  E' ->  +TE' | ε
  T' ->  *FT' | ε
```

Results: Thus, the python program to implement elimination of left recursion is executed successfully and tested with various samples.

Ex No: 04 LEFT FACTORING THE GIVEN GRAMMAR

Date:

Aim: To write a python program to implement Left Factoring for given sample grammar.

Algorithm:

Left factoring is a grammar transformation that is useful for producing a grammar suitable for predictive, or top-down, parsing. When the choice between two alternative A-productions is not clear, we may be able to rewrite the productions to defer the decision until enough of the input has been seen that we can make the right choice.

1. For each nonterminal A, find the longest prefix α common to two or more of its alternatives.
2. If a=∈, there is a non-trivial common prefix and hence replace all of A-productions,
   $A \rightarrow \alpha\beta1 | \alpha\beta2 | \ldots.. | \alpha\beta n | \gamma$, where γ represents all alternatives that do not begin with α,
   by $A \rightarrow \alpha A' | \gamma$ $A' \rightarrow \beta1 | \beta2 | \ldots\ldots | \beta n$
3. Here, A' is new non terminal. Repeatedly apply this transformation until two alternatives for a nonterminal has common prefix.

Source code:

```
e = '\u03b5' p = []  class Prod:
def __init__(self, name, products):
        self.name = name
self.products = products
     def
print(self):
        s = f'{self.name} -> '
for prod in self.products:
            s += f' {prod} |'
s = s.rstrip('|')
print(s)
 def trans():     a =
p[0]     temp =
a.products
temp.sort()
    a.products = []
     while temp:          group = []
alpha = ''          beta = []
for i in range(1, len(temp)):
```

```
if temp[0][0] == temp[i][0]:
group.append(temp[i])

if group:
            group.insert(0, temp[0])
            temp = [j for j in temp if j not in group]
             for j in
range(len(group)):
                group[j] += e
             for c in
group[0]:
                f1 = 0
for j in group:
if c != j[0]:
f1 = 1                  if f1:
beta = group
break                  else:
                    alpha += group[0][0]
                                for j in
range(len(group)):
group[j] = group[j][1:]
             for          j          in
range(len(beta)):                    if
beta[j][0] != e:
                    beta[j] = beta[j][:-1]

            a.products.append(alpha + alpha[0] + "'")
            p.append(Prod(alpha[0] + "'", beta))
else:
            a.products.append(temp[0])
temp.pop(0)              n = int(input("Enter the
number of productions: ")) for i in range(n):
    ip = input(f"Enter production {i+1}: ")
name, prods = ip.split(' -> ')
products = prods.split(' | ')
    p.append(Prod(name, products))
print('Productions:') for x in p:
    x.print()
print('Transforming...') trans()
print('Transformed
Productions:') for x in p:
    x.print()
```

Sample Input and Output:

```
Enter the number of productions: 1
Enter production 1: A -> ABs | AB | Sed | Swa | p
Productions:
A ->  ABs | AB | Sed | Swa | p
Transforming...
Transformed Productions:
A ->  ABA' | SS' | p
A' ->  ε | s  S'
->  ed | wa
```

Results:

Thus, the python program to implement elimination of left factoring is executed successfully and tested with various samples.

Ex No: 05 COMPUTATION OF FIRST AND FOLLOW SETS

Date:

Aim:

To write a python program to Compute First and Follow Sets for given sample grammar.

Algorithm:

1. Initialize an empty list `p` to store production rules.
2. Define the `Prod` class with attributes `name`, `products`, `first`, and `follow`.
3. Define a function `is_terminal` to check if a symbol is a terminal.
4. Define a function `find_prod` to find a production by name.
5. Define a function `calc_first` to calculate the `first` set for each non-terminal symbol.
6. Define a function `calc_follow` to calculate the `follow` set for each non-terminal symbol.
7. Define a function `find_follow` to find the `follow` set for a given non-terminal symbol.
8. Define a function `first` to retrieve the `first` set for a given non-terminal symbol.
9. Define a function `follow` to retrieve the `follow` set for a given non-terminal symbol.
10. Accept input for the number of productions `n`.
    a. For each production:
    b. Input the production rule in the format `A -> B1 | B2 | ... | Bn`.
    c. Split the input to extract the non-terminal symbol `name` and the list of productions `prods`.
    d. Split the list of productions `prods` into individual productions and create a `Prod` object for each non-terminal symbol.
11. Calculate the `first` and `follow` sets for each non-terminal symbol using `calc_first` and `calc_follow` functions.
12. Print the `first` and `follow` sets for each non-terminal symbol.

Source code:

```
import re p=[] class Prod:     def
__init__(self, name, products):
        self.name=name
self.products=products
self.first=[]         self.follow=[] def
is_terminal(s):     if
re.match(re.compile('^[A-Z]$'),s):
        return False

  else:
```

```
        return True #find production by
name: def find_prod(name):     for x
in p:         if x.name == name:
return x def first(name):     for x in
p:         if name == x.name:
return x.first def follow(name):
for x in p:         if name == x.name:
return x.follow def calc_first():
for i in reversed(range(len(p))):
for x in p[i].products:             if
is_terminal(x[0]):
p[i].first.append(x[0])
else:
                f = find_prod(x[0]).first
p[i].first.extend(f)                 c=1
while 'e' in f:                     if
is_terminal(x[c]):
                        f=x[c]
else:
                        f=find_prod(x[c]).first
p[i].first.extend(f)                     c+=1
if c == len(x):                         break
p[i].first = list(set(p[i].first)) def
calc_follow():
    p[0].follow.append('$')
for x in p:
        find_follow(x) def
find_follow(x):     for y in p:
for pr in y.products:
for c in range(len(pr)):
if pr[c] == x.name:
if c+1 >= len(pr):
                        x.follow.extend(y.follow)
elif is_terminal(pr[c+1]):
                        x.follow.append(pr[c+1])
elif 'e' not in first(pr[c+1]):
                        x.follow.extend(first(pr[c+1]))
elif follow(pr[c+1]):
                        x.follow.extend(first(pr[c+1]) + follow(pr[c+1]))
else:
                        x.follow.extend(first(pr[c+1]) +
                        find_follow(find_prod(pr[c+1])))
```

```
                    x.follow = list(set(x.follow)-{'e'})
return x.follow n = int(input("No of production: "))
print("Epsilon = e") for i in range(n):
    ip = input(f"Production {i+1}: ")
name, prods = ip.split(' -> ')
products = prods.split(' | ')
    p.append(Prod(name, products))
calc_first() calc_follow()

#print first and follow for
x in p:
    print(f'first({x.name}) = {x.first}') for
x in p:
    print(f'follow({x.name}) = {x.follow}')
```

Sample Input and Output:

```
No of production: 5
Epsilon = e
Production 1: E -> TX
Production 2: X -> +TX | e
Production 3: T -> FY
Production 4: Y -> *FY | e
Production 5: F -> (E) | i
first(E) = ['(', 'i'] first(X)
= ['e', '+'] first(T) = ['(',
'i'] first(Y) = ['e', '*']
first(F) = ['(', 'i'] follow(E)
= [')', '$'] follow(X) = [')',
'$'] follow(T) = ['+', ')',
'$'] follow(Y) = ['+', ')',
'$'] follow(F) = ['+', '*',
')', '$']
```

Results:

Thus, the python program to implement the Computation of First and Follow sets is executed successfully and tested with various samples.

Ex No: 06 IMPLEMENTATION OF RECURSIVE DESCENT PARSER

Date:

Aim:

To write a Python program that uses a Recursive Descent Parser to check if a given string is valid according to a specified grammar.

Algorithm:

Recursive descent parsing is a top-down parsing technique for context-free grammars that uses recursive functions to parse the input string. Each non-terminal symbol in the grammar has a corresponding parsing function. The parsing functions are called recursively to parse the input string, and they check if the current input character matches the expected symbol. Recursive descent parsing is simple and widely used, but left recursion in the grammar can cause infinite recursion and must be eliminated.

Input grammar:

```
E -> TE'
E' -> +TE' | ε T
-> FT'
T' -> *FT' | ε
F -> ε | i
```

1. Define functions `match(a)`, `F()`, `Tx()`, `T()`, `Ex()`, and `E()` to handle the grammar rules.
2. Initialize `s` as the input string converted to a list and `i` as the current index.
3. In `match(a)`, check if the current character matches `a` and increment `i` if it does.
4. In `F()`, check if the current character is '(' and if so, recursively check E and match ')'; if not, check if the current character is 'i'.
5. In `Tx()`, if the current character is '*', recursively check F and then Tx(); otherwise, return True.
6. In `T()`, recursively check F and then Tx().
7. In `Ex()`, if the current character is '+', recursively check T and then Ex(); otherwise, return True.
8. In `E()`, recursively check T and then Ex().
9. Call `E()` to check if the input string satisfies the grammar rules.
10. If `E()` returns True and `i` reaches the end of the input string, print "String is accepted".
11. If `E()` returns True but `i` does not reach the end of the input string, print "String is not accepted".
12. If `E()` returns False, print "String is not accepted".

Source code:

```
print("Recursive Descent Parsing For following grammar\n")
print("E->TE'\nE'->+TE'/@\nT->FT'\nT'->*FT'/@\nF-
>(E)/i\n") print("Enter the string want to be checked\n")
global s s=list(input()) global i i=0 def match(a):
global s     global i     if(i>=len(s)):         return
False     elif(s[i]==a):         i+=1         return True
else:
        return False def
F():
if(match("(")):
if(E()):
            return match(")")
else:
            return False
else:
        return match("i") def
Tx():
    if(match("*")):
if(F()):
            return Tx()
else:
            return False
else:
        return True
def T():
if(F()):
        return Tx()
else:
        return False def
Ex():
if(match("+")):
if(T()):
            return Ex()
else:
            return False
else:
        return True
def E():
if(T()):
```

```
        return Ex()
    else:
        return False
    if(E()):
    if(i==len(s)):
        print("String is accepted")
    else:
        print("String is not accepted") else:
      print("string is not accepted")
```

Sample Input and Output:

```
Recursive Descent Parsing For following grammar
E->TE'
E'->+TE'/@
T->FT'
T'->*FT'/@
F->(E)/i

Enter the string want to be checked
 i+i*(i)
String is accepted
```

Result:

Thus, the python program to check if a given string is valid using Recursive Descent Parser is executed successfully and tested with various samples

Ex No: 07 IMPLEMENTATION OF SHIFT REDUCE PARSING ALGORITHM

Date:

Aim:

To write a python program to implement the shift-reduce parsing algorithm.

Algorithm:

Shift-reduce parsing is a bottom-up parsing technique for context-free grammars that involves shifting input symbols onto a stack and reducing stack symbols using production rules. It is used in LR parsing, SLR parsing, and LALR parsing algorithms. The parsing process continues until the entire input string has been parsed or an error is detected. If the parsing process ends with the stack containing only the start symbol and the input buffer being empty, the input string is accepted; otherwise, it is rejected.

A lexical token is a sequence of characters that can be treated as a unit in the grammar of the programming languages The types of tokens are identifier, numbers, operators, keywords, special symbols etc.

While the input buffer is not empty:

1. For each production in the start symbol's right-hand side:
   If the production is in the stack, replace it with the start symbol and print a reduction action.
2. If the input buffer has more than one character:
   Add the first character of the input buffer to the stack and shift it to the right.
3. If the stack is equal to the end-of-string symbol followed by the start symbol, check if the input buffer is also empty.
   If the input buffer is empty, print "Accepted".
   If the input buffer is not empty, print "Rejected" and break the loop.

Source code:

```
gram = {
"S": ["S+S", "S*S",'S-S','(S)', "id"]
} start = "S"
inp = "(id+id)$"
stack = "$"
print(f'{"Stack": <15}' + "|" + f'{"Input Buffer": <15}' + "|" + 'Parsing
      Action') print(f'{"-":-<50}')
while True:     i = 0     for i in
range (len(gram[start])):         if
gram[start][i] in stack:
            stack = stack.replace(gram[start][i], start)
            print(f'{stack: <15}' + "|" + f'{inp: <15}' + "|" + f'Reduce >
                 {gram[start][i]}')
```

```
    if len(inp) > 1:          stack += inp[0]          inp = inp[1:]
print(f'{stack: <15}' + "|" + f'{inp: <15}' + "|" + 'Shift')     if
stack == ("$" + start):          if inp == '$':
            print(f'{stack: <15}' + "|" + f'{inp: <15}' + "|" + 'Accepted')
else:                  print(f'{stack: <15}' + "|" + f'{inp: <15}' + "|" +
'Rejected')         break
```

Sample Input and Output:

```
Stack          |Input Buffer   |Parsing Action
-------------------------------------------------
$(             |id+id)$        |Shift
$(i            |d+id)$         |Shift
$(id           |+id)$          |Shift
$(S            |+id)$          |Reduce > id
$(S+           |id)$           |Shift
$(S+i          |d)$            |Shift
$(S+id         |)$             |Shift
$(S+S          |)$             |Reduce > id
$(S+S)         |$              |Shift
$(S)           |$              |Reduce > S+S
$S             |$              |Reduce > (S)
$S             |$              |Accepted
```

Result:

Thus, the python program to implement the shift-reduce parsing algorithm is executed successfully and tested with various samples.

Ex No: 08 IMPLEMENTATION OF INTERMEDIATE CODE GENERATOR

Date:

Aim:

To write a python program to implement Intermediate Code Generator.

Algorithm:

Intermediate code generation is a step-in compiler optimization that involves translating high-level source code into an intermediate representation for further analysis and optimization. This intermediate representation, often in the form of assembly-like instructions, is easier to analyze and optimize than high-level source code.

1. Define the set of operators `OPERATORS` and the precedence dictionary `PRI`.
2. Implement the `infix_to_postfix` function that takes a string formula as input and returns a postfix string.
3. Initialize an empty stack `stack` and an empty output string `output`.
4. Iterate through each character `ch` in the formula.
   4.1. If `ch` is not an operator, append it to the output string.
   4.2. If `ch` is an opening parenthesis, push it onto the stack.
   4.3. If `ch` is a closing parenthesis, pop and output stack elements until an opening parenthesis is reached.
   4.4. If `ch` is an operator, pop and output stack elements with higher or equal precedence until an operator with lower precedence or an opening parenthesis is reached.
5. After the loop, output any remaining elements in the stack.
6. Implement the `generate3AC` function that takes a postfix string `pos` as input and generates three-address code.
   6.1. Initialize an empty expression stack `exp_stack` and a temporary variable counter `t`.
   6.2. Iterate through each character `i` in the postfix string.
      6.2.1. If `i` is not an operator, push it onto the expression stack.
      6.2.2. If `i` is an operator, pop and output the top two elements from the expression stack, perform the operation, and push the result onto the expression stack.
   6.3.After the loop, the expression stack should contain only the final result.
7. Get the input expression from the user and convert it to postfix form using `infix_to_postfix`.
8. Generate three-address code using `generate3AC`.

Source code:

```
OPERATORS = set(['+', '-', '*', '/', '(', ')']) PRI = {'+':1, '-':1, '*':2,
'/':2} def infix_to_postfix(formula):
        stack = []     output = ''
    for ch in formula:         if
    ch not in OPERATORS:
                output += ch
    elif ch == '(':
                stack.append('(')         elif ch
    == ')':             while stack and stack[-
    1] != '(':
                    output += stack.pop()             stack.pop()         else:
    while stack and stack[-1] != '(' and PRI[ch] <= PRI[stack[-1]]:
                    output += stack.pop()
    stack.append(ch)
        # leftover
    while stack:
            output += stack.pop()     print(f'POSTFIX:
    {output}')     return output def
    generate3AC(pos):     print("### THREE ADDRESS
    CODE GENERATION ###")     exp_stack = []     t =
    1     for i in pos:         if i not in
    OPERATORS:             exp_stack.append(i)
    else:
                print(f't{t} := {exp_stack[-2]} {i} {exp_stack[-1]}')
    exp_stack=exp_stack[:-2]             exp_stack.append(f't{t}')
    t+=1 expres = input("INPUT THE EXPRESSION: ") pos =
    infix_to_postfix(expres) generate3AC(pos)
```

Sample Input and Output:

```
INPUT THE EXPRESSION: a=3+4*(8-7*(c-b)+2)
POSTFIX: a=3487cb-*-2+*+
### THREE ADDRESS CODE GENERATION ###
t1 := c - b t2 := 7 * t1 t3 := 8 -
t2 t4 := t3 + 2 t5 := 4 * t4
t6 := 3 + t5
```

Result:

Thus, the python program to implement Intermediate Code Generator is executed successfully and tested with various samples.