Eram Khan
Roll no 14

COMPILER
MINI PROJECT

Aim: Design a predictive parser for a given language

Code:

```
def removeLeftRecursion(rulesDiction):

    store = {}

    for lhs in rulesDiction:

        alphaRules = []
        betaRules = []
        allrhs = rulesDiction[lhs]
        for subrhs in allrhs:
            if subrhs[0] == lhs:
                alphaRules.append(subrhs[1:])
            else:
                betaRules.append(subrhs)
        if len(alphaRules) != 0:

            lhs_ = lhs + "'"
            while (lhs_ in rulesDiction.keys()) \
                    or (lhs_ in store.keys()):
                lhs_ += "'"

            for b in range(0, len(betaRules)):
                betaRules[b].append(lhs_)
```

```
            rulesDiction[lhs] = betaRules

            for a in range(0, len(alphaRules)):
                alphaRules[a].append(lhs_)
            alphaRules.append(['#'])

            store[lhs_] = alphaRules

    for left in store:
        rulesDiction[left] = store[left]
    return rulesDiction


def LeftFactoring(rulesDiction):


    newDict = {}

    for lhs in rulesDiction:

        allrhs = rulesDiction[lhs]

        temp = dict()
        for subrhs in allrhs:
            if subrhs[0] not in list(temp.keys()):
                temp[subrhs[0]] = [subrhs]
            else:
                temp[subrhs[0]].append(subrhs)
```

```
    new_rule = []

    tempo_dict = {}
    for term_key in temp:

        allStartingWithTermKey = temp[term_key]
        if len(allStartingWithTermKey) > 1:

            lhs_ = lhs + """
            while (lhs_ in rulesDiction.keys()) \
                    or (lhs_ in tempo_dict.keys()):
                lhs_ += """

            new_rule.append([term_key, lhs_])

            ex_rules = []
            for g in temp[term_key]:
                ex_rules.append(g[1:])
            tempo_dict[lhs_] = ex_rules
        else:

            new_rule.append(allStartingWithTermKey[0])

    newDict[lhs] = new_rule

    for key in tempo_dict:
        newDict[key] = tempo_dict[key]
return newDict
```

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```
def first(rule):
    global rules, nonterm_userdef, \
        term_userdef, diction, firsts

    if len(rule) != 0 and (rule is not None):
        if rule[0] in term_userdef:
            return rule[0]
        elif rule[0] == '#':
            return '#'


    if len(rule) != 0:
        if rule[0] in list(diction.keys()):
            fres = []
            rhs_rules = diction[rule[0]]
            for itr in rhs_rules:
                indivRes = first(itr)
                if type(indivRes) is list:
                    for i in indivRes:
                        fres.append(i)
                else:
                    fres.append(indivRes)


            if '#' not in fres:
                return fres
            else:
```

```
            newList = []
            fres.remove('#')
            if len(rule) > 1:
                ansNew = first(rule[1:])
                if ansNew != None:
                    if type(ansNew) is list:
                        newList = fres + ansNew
                    else:
                        newList = fres + [ansNew]
                else:
                    newList = fres
                return newList

            fres.append('#')
            return fres



def follow(nt):
    global start_symbol, rules, nonterm_userdef, \
        term_userdef, diction, firsts, follows

    solset = set()
    if nt == start_symbol:

        solset.add('$')


    for curNT in diction:
```

```
rhs = diction[curNT]

for subrule in rhs:
    if nt in subrule:

        while nt in subrule:
            index_nt = subrule.index(nt)
            subrule = subrule[index_nt + 1:]

            if len(subrule) != 0:

                res = first(subrule)

                if '#' in res:
                    newList = []
                    res.remove('#')
                    ansNew = follow(curNT)
                    if ansNew != None:
                        if type(ansNew) is list:
                            newList = res + ansNew
                        else:
                            newList = res + [ansNew]
                    else:
                        newList = res
                    res = newList
            else:

                if nt != curNT:
                    res = follow(curNT)
```

```
                if res is not None:
                    if type(res) is list:
                        for g in res:
                            solset.add(g)
                    else:
                        solset.add(res)
    return list(solset)


def computeAllFirsts():
    global rules, nonterm_userdef, \
        term_userdef, diction, firsts
    for rule in rules:
        k = rule.split("->")
        # remove un-necessary spaces
        k[0] = k[0].strip()
        k[1] = k[1].strip()
        rhs = k[1]
        multirhs = rhs.split('|')
        # remove un-necessary spaces
        for i in range(len(multirhs)):
            multirhs[i] = multirhs[i].strip()
            multirhs[i] = multirhs[i].split()
        diction[k[0]] = multirhs

    print(f"\nRules: \n")
    for y in diction:
        print(f"{y}->{diction[y]}")
    print(f"\nAfter elimination of left recursion:\n")
```

```
diction = removeLeftRecursion(diction)
for y in diction:
    print(f"{y}->{diction[y]}")
print("\nAfter left factoring:\n")

diction = LeftFactoring(diction)
for y in diction:
    print(f"{y}->{diction[y]}")



for y in list(diction.keys()):
    t = set()
    for sub in diction.get(y):
        res = first(sub)
        if res != None:
            if type(res) is list:
                for u in res:
                    t.add(u)
            else:
                t.add(res)



    firsts[y] = t

print("\nCalculated firsts: ")
key_list = list(firsts.keys())
index = 0
for gg in firsts:
    print(f"first({key_list[index]}) "
```

```
            f"=> {firsts.get(gg)}")
        index += 1



def computeAllFollows():
    global start_symbol, rules, nonterm_userdef,\
        term_userdef, diction, firsts, follows
    for NT in diction:
        solset = set()
        sol = follow(NT)
        if sol is not None:
            for g in sol:
                solset.add(g)
        follows[NT] = solset

    print("\nCalculated follows: ")
    key_list = list(follows.keys())
    index = 0
    for gg in follows:
        print(f"follow({key_list[index]})"
            f" => {follows[gg]}")
        index += 1



def createParseTable():
    import copy
    global diction, firsts, follows, term_userdef
    print("\nFirsts and Follow Result table\n")
```

```
mx_len_first = 0
mx_len_fol = 0
for u in diction:
    k1 = len(str(firsts[u]))
    k2 = len(str(follows[u]))
    if k1 > mx_len_first:
        mx_len_first = k1
    if k2 > mx_len_fol:
        mx_len_fol = k2

print(f"{{:<{10}}} "
      f"{{:<{mx_len_first + 5}}} "
      f"{{:<{mx_len_fol + 5}}}"
      .format("Non-T", "FIRST", "FOLLOW"))
for u in diction:
    print(f"{{:<{10}}} "
          f"{{:<{mx_len_first + 5}}} "
          f"{{:<{mx_len_fol + 5}}}"
          .format(u, str(firsts[u]), str(follows[u])))

ntlist = list(diction.keys())
terminals = copy.deepcopy(term_userdef)
terminals.append('$')


mat = []
for x in diction:
    row = []
    for y in terminals:
```

```
        row.append('')

    mat.append(row)


grammar_is_LL = True


for lhs in diction:
    rhs = diction[lhs]
    for y in rhs:
        res = first(y)

        if '#' in res:
            if type(res) == str:
                firstFollow = []
                fol_op = follows[lhs]
                if fol_op is str:
                    firstFollow.append(fol_op)
                else:
                    for u in fol_op:
                        firstFollow.append(u)
                res = firstFollow
            else:
                res.remove('#')
                res = list(res) +\
                      list(follows[lhs])

        ttemp = []
        if type(res) is str:
```

```
            ttemp.append(res)
            res = copy.deepcopy(ttemp)
        for c in res:
            xnt = ntlist.index(lhs)
            yt = terminals.index(c)
            if mat[xnt][yt] == '':
                mat[xnt][yt] = mat[xnt][yt] \
                            + f"{lhs}->{' '.join(y)}"
            else:

                if f"{lhs}->{y}" in mat[xnt][yt]:
                    continue
                else:
                    grammar_is_LL = False
                    mat[xnt][yt] = mat[xnt][yt] \
                                + f",{lhs}->{' '.join(y)}"


print("\nGenerated parsing table:\n")
frmt = "{:>12}" * len(terminals)
print(frmt.format(*terminals))

j = 0
for y in mat:
    frmt1 = "{:>12}" * len(y)
    print(f"{ntlist[j]} {frmt1.format(*y)}")
    j += 1

return (mat, grammar_is_LL, terminals)
```

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```
def validateStringUsingStackBuffer(parsing_table, grammarll1,
                                   table_term_list, input_string,
                                   term_userdef,start_symbol):

    print(f"\nValidate String => {input_string}\n")


    if grammarll1 == False:
        return f"\nInput String = " \
               f"\"{input_string}\"\n" \
               f"Grammar is not LL(1)"



    stack = [start_symbol, '$']
    buffer = []


    input_string = input_string.split()
    input_string.reverse()
    buffer = ['$'] + input_string

    print("{:>20} {:>20} {:>20}".
          format("Buffer", "Stack","Action"))

    while True:

        if stack == ['$'] and buffer == ['$']:
            print("{:>20} {:>20} {:>20}"
```

```
        .format(' '.join(buffer),
                ' '.join(stack),
                "Valid"))
    return "\nValid String!"
elif stack[0] not in term_userdef:

    x = list(diction.keys()).index(stack[0])
    y = table_term_list.index(buffer[-1])
    if parsing_table[x][y] != '':

        entry = parsing_table[x][y]
        print("{:>20} {:>20} {:>25}".
              format(' '.join(buffer),
                     ' '.join(stack),
                     f"T[{stack[0]}][{buffer[-1]}] = {entry}"))
        lhs_rhs = entry.split("->")
        lhs_rhs[1] = lhs_rhs[1].replace('#', '').strip()
        entryrhs = lhs_rhs[1].split()
        stack = entryrhs + stack[1:]
    else:
        return f"\nInvalid String! No rule at " \
               f"Table[{stack[0]}][{buffer[-1]}]."
else:

    if stack[0] == buffer[-1]:
        print("{:>20} {:>20} {:>20}"
              .format(' '.join(buffer),
                      ' '.join(stack),
                      f"Matched:{stack[0]}"))
        buffer = buffer[:-1]
```

```
            stack = stack[1:]
        else:
            return "\nInvalid String! " \
                "Unmatched terminal symbols"



sample_input_string = None



rules=["S -> A k O",
      "A -> A d | a B | a C",
      "C -> c",
      "B -> b B C | r"]

nonterm_userdef=['A','B','C']
term_userdef=['k','O','d','a','c','b','r']
sample_input_string="a r k O"


diction = {}
firsts = {}
follows = {}


computeAllFirsts()

start_symbol = list(diction.keys())[0]
```

```
computeAllFollows()



(parsing_table, result, tabTerm) = createParseTable()



if sample_input_string != None:
    validity = validateStringUsingStackBuffer(parsing_table, result,
                                        tabTerm, sample_input_string,
                                        term_userdef,start_symbol)
    print(validity)
else:
    print("\nNo input String detected")
```

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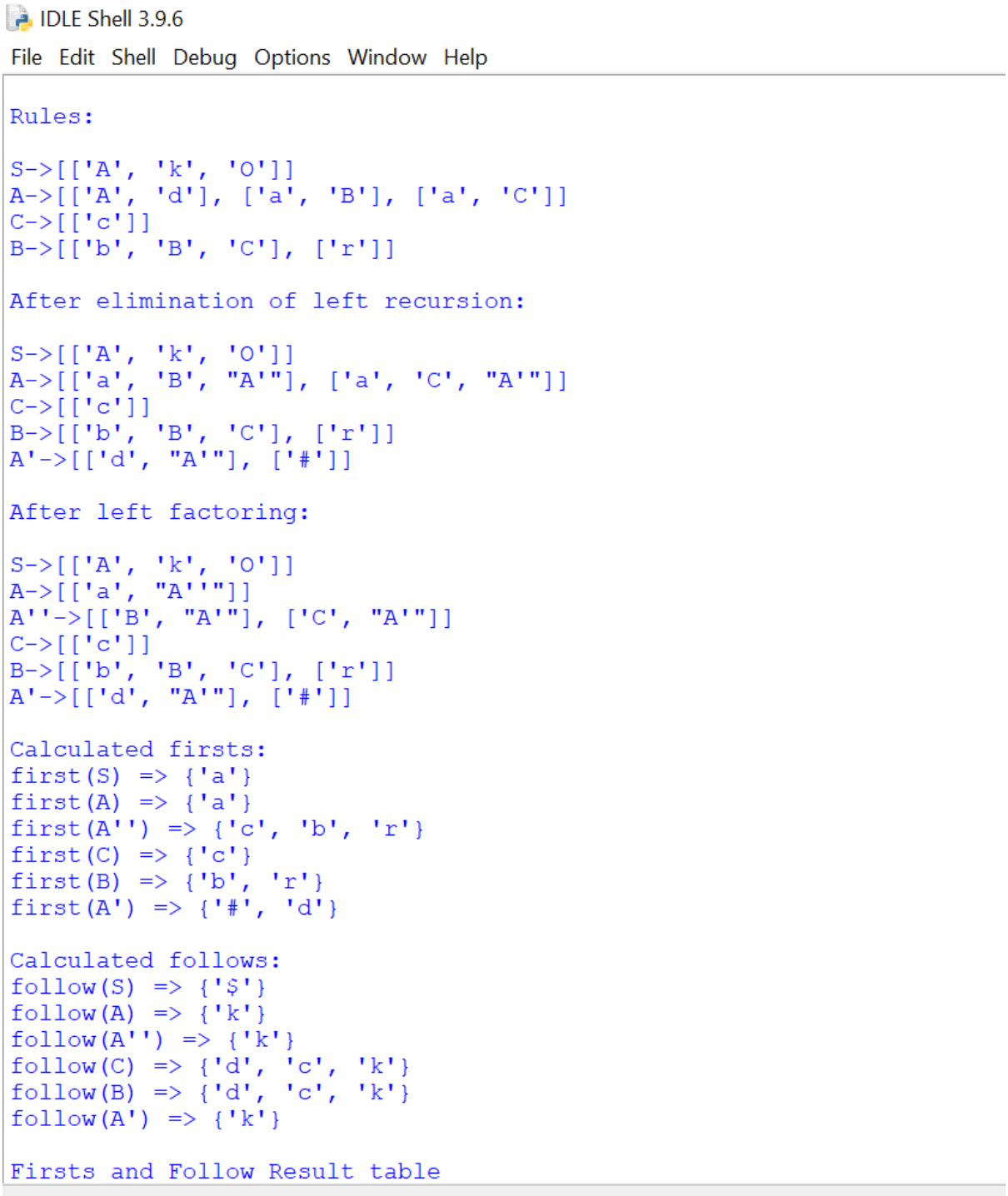
Output:



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IDLE Shell 3.9.6

File Edit Shell Debug Options Window Help

```
follow(A) => {'k'}
follow(A'') => {'k'}
follow(C) => {'d', 'c', 'k'}
follow(B) => {'d', 'c', 'k'}
follow(A') => {'k'}

Firsts and Follow Result table

Non-T       FIRST                FOLLOW
S           {'a'}                {'$'}
A           {'a'}                {'k'}
A''         {'c', 'b', 'r'}      {'k'}
C           {'c'}                {'d', 'c', 'k'}
B           {'b', 'r'}           {'d', 'c', 'k'}
A'          {'#', 'd'}           {'k'}

Generated parsing table:

            k           O           d           a           c           b           r           $
S                                               S->A k O
A                                               A->a A''
A''                                                         A''->C A'   A''->B A'   A''->B A'
C                                                              C->c
B                                                                       B->b B C        B->r
A'          A'->#                   A'->d A'

Validate String => a r k O

              Buffer                Stack               Action
           $ O k r a                  S $          T[S][a] = S->A k O
           $ O k r a                A k O $        T[A][a] = A->a A''
           $ O k r a              a A'' k O $            Matched:a
             $ O k r              A'' k O $     T[A''][r] = A''->B A'
             $ O k r              B A' k O $           T[B][r] = B->r
             $ O k r              r A' k O $            Matched:r
               $ O k              A' k O $          T[A'][k] = A'->#
               $ O k                k O $             Matched:k
                 $ O                  O $             Matched:O
                   $                  $                 Valid

Valid String!
>>>
```