Lab-11
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Sec-B

Ques1- WAP to implement 3 address code?

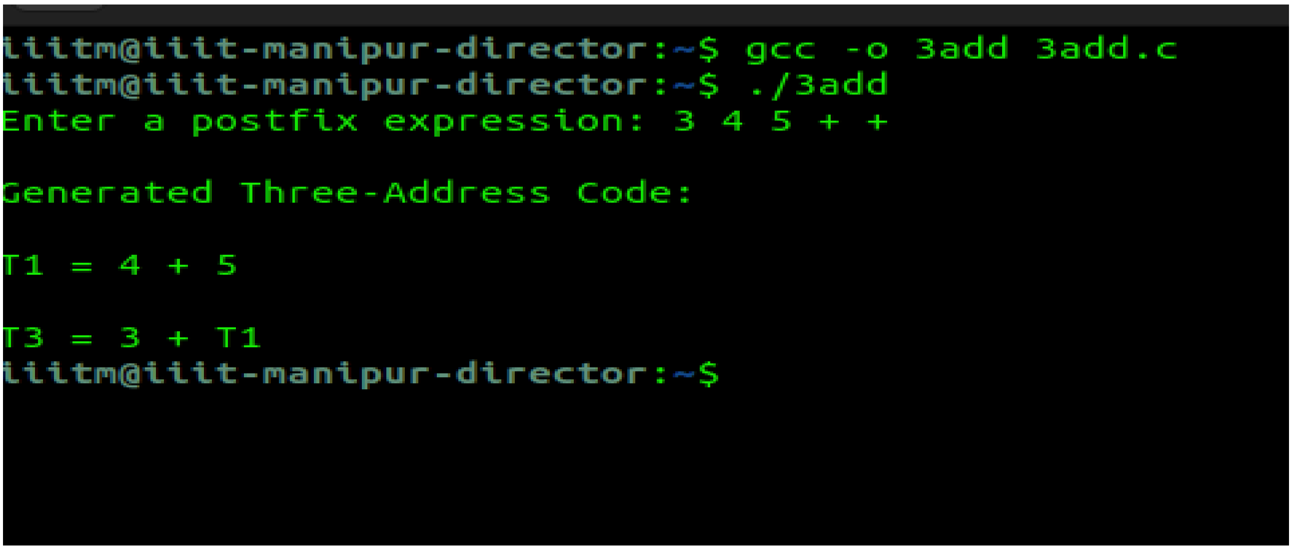
Code-

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>

#define MAX_CODE 100
#define MAX_TEMP 10

typedef struct {
    char code[MAX_CODE][50];  // Store TAC
instructions
    int tempCounter;          // Counter for
temporary variables
} TACGenerator;
```

```
void initTACGenerator(TACGenerator *tac) {
    tac->tempCounter = 0;
}

char* newTemp(TACGenerator *tac) {
    tac->tempCounter++;
    static char temp[10];
    sprintf(temp, "T%d", tac->tempCounter);
    return temp;
}

void emit(TACGenerator *tac, const char
*operation, const char *arg1, const char *arg2,
const char *result) {
    sprintf(tac->code[tac->tempCounter], "%s =
%s %s %s", result, arg1, operation, arg2);
    tac->tempCounter++;
}

int isIdentifier(const char *token) {
    return isalpha(token[0]);  // Check if the first
character is alphabetic
}

int isNumber(const char *token) {
    return isdigit(token[0]);   // Check if the first
character is a digit
}
```

```
void generateTAC(TACGenerator *tac, char
*expression) {
    char *tokens[MAX_CODE];
    char *token;
    char stack[MAX_CODE][10];
    int stackTop = -1;

    // Tokenize the expression
    token = strtok(expression, " ");
    int tokenCount = 0;

    while (token != NULL) {
        tokens[tokenCount++] = token;
        token = strtok(NULL, " ");
    }

    for (int i = 0; i < tokenCount; i++) {
        token = tokens[i];

        if (isIdentifier(token) || isNumber(token)) {
            strcpy(stack[++stackTop], token);
        } else {  // Operator
            char right[10], left[10], temp[10];
            strcpy(right, stack[stackTop--]);
            strcpy(left, stack[stackTop--]);
            strcpy(temp, newTemp(tac));
            emit(tac, token, left, right, temp);
```

```
            strcpy(stack[++stackTop], temp);
        }
    }
}

void displayTAC(const TACGenerator *tac) {
    for (int i = 0; i < tac->tempCounter; i++) {
        printf("%s\n", tac->code[i]);
    }
}

int main() {
    TACGenerator tacGen;
    initTACGenerator(&tacGen);

    char expression[100];

    // Example input: "a b + c d * -"
    printf("Enter a postfix expression: ");
    fgets(expression, sizeof(expression), stdin);
    expression[strcspn(expression, "\n")] = 0;  //
Remove newline character

    generateTAC(&tacGen, expression);
    printf("\nGenerated Three-Address Code:\n");
    displayTAC(&tacGen);

    return 0;}
```



Ques- WAP to implement SLR parsing?

Code-

```
# SLR(1)

import copy

# perform grammar augmentation
def grammarAugmentation(rules,
nonterm_userdef,
                                        start_symbol):

      # newRules stores processed output rules
      newRules = []

      # create unique 'symbol' to
      # - represent new start symbol
      newChar = start_symbol + "'"
      while (newChar in nonterm_userdef):
```

```
        newChar += "'"

    # adding rule to bring start symbol to RHS
    newRules.append([newChar,
                     ['.', start_symbol]])

    # new format => [LHS,[.RHS]],
    # can't use dictionary since
    # - duplicate keys can be there
    for rule in rules:

        # split LHS from RHS
        k = rule.split("->")
        lhs = k[0].strip()
        rhs = k[1].strip()

        # split all rule at '|'
        # keep single derivation in one rule
        multirhs = rhs.split('|')
        for rhs1 in multirhs:
            rhs1 = rhs1.strip().split()

            # ADD dot pointer at start of RHS
            rhs1.insert(0, '.')
            newRules.append([lhs, rhs1])
    return newRules
```

```
# find closure
def findClosure(input_state, dotSymbol):
    global start_symbol, \
        separatedRulesList, \
        statesDict

    # closureSet stores processed output
    closureSet = []

    # if findClosure is called for
    # - 1st time i.e. for I0,
    # then LHS is received in "dotSymbol",
    # add all rules starting with
    # - LHS symbol to closureSet
    if dotSymbol == start_symbol:
        for rule in separatedRulesList:
            if rule[0] == dotSymbol:
                closureSet.append(rule)
    else:
        # for any higher state than I0,
        # set initial state as
        # - received input_state
        closureSet = input_state

    # iterate till new states are
    # - getting added in closureSet
    prevLen = -1
    while prevLen != len(closureSet):
```

```
        prevLen = len(closureSet)

        # "tempClosureSet" - used to eliminate
        # concurrent modification error
        tempClosureSet = []

        # if dot pointing at new symbol,
        # add corresponding rules to tempClosure
        for rule in closureSet:
            indexOfDot = rule[1].index('.')
            if rule[1][-1] != '.':
                dotPointsHere =
rule[1][indexOfDot + 1]
                for in_rule in separatedRulesList:
                    if dotPointsHere == in_rule[0]
and \
                                in_rule not in
tempClosureSet:

    tempClosureSet.append(in_rule)

        # add new closure rules to closureSet
        for rule in tempClosureSet:
            if rule not in closureSet:
                closureSet.append(rule)
    return closureSet
```

```
def compute_GOTO(state):
    global statesDict, stateCount

    # find all symbols on which we need to
    # make function call - GOTO
    generateStatesFor = []
    for rule in statesDict[state]:
        # if rule is not "Handle"
        if rule[1][-1] != '.':
            indexOfDot = rule[1].index('.')
            dotPointsHere = rule[1][indexOfDot +
1]
            if dotPointsHere not in
generateStatesFor:

    generateStatesFor.append(dotPointsHere)

    # call GOTO iteratively on all symbols pointed
by dot
    if len(generateStatesFor) != 0:
        for symbol in generateStatesFor:
            GOTO(state, symbol)
    return


def GOTO(state, charNextToDot):
    global statesDict, stateCount, stateMap
```

```
# newState - stores processed new state
newState = []
for rule in statesDict[state]:
    indexOfDot = rule[1].index('.')
    if rule[1][-1] != '.':
        if rule[1][indexOfDot + 1] == \
                charNextToDot:
            # swapping element with dot,
            # to perform shift operation
            shiftedRule = copy.deepcopy(rule)
            shiftedRule[1][indexOfDot] = \
                shiftedRule[1][indexOfDot + 1]
            shiftedRule[1][indexOfDot + 1] = '.'
            newState.append(shiftedRule)

# add closure rules for newState
# call findClosure function iteratively
# - on all existing rules in newState

# addClosureRules - is used to store
# new rules temporarily,
# to prevent concurrent modification error
addClosureRules = []
for rule in newState:
    indexDot = rule[1].index('.')
    # check that rule is not "Handle"
    if rule[1][-1] != '.':
        closureRes = \
```

```
                findClosure(newState,
rule[1][indexDot + 1])
            for rule in closureRes:
                if rule not in addClosureRules \
                        and rule not in newState:
                    addClosureRules.append(rule)

    # add closure result to newState
    for rule in addClosureRules:
        newState.append(rule)

    # find if newState already present
    # in Dictionary
    stateExists = -1
    for state_num in statesDict:
        if statesDict[state_num] == newState:
            stateExists = state_num
            break

    # stateMap is a mapping of GOTO with
    # its output states
    if stateExists == -1:

        # if newState is not in dictionary,
        # then create new state
        stateCount += 1
        statesDict[stateCount] = newState
```

```
            stateMap[(state, charNextToDot)] =
stateCount
        else:

            # if state repetition found,
            # assign that previous state number
            stateMap[(state, charNextToDot)] =
stateExists
        return



def generateStates(statesDict):
        prev_len = -1
        called_GOTO_on = []

        # run loop till new states are getting added
        while (len(statesDict) != prev_len):
            prev_len = len(statesDict)
            keys = list(statesDict.keys())

            # make compute_GOTO function call
            # on all states in dictionary
            for key in keys:
                if key not in called_GOTO_on:
                    called_GOTO_on.append(key)
                    compute_GOTO(key)
        return
```

```
# calculation of first
# epsilon is denoted by '#' (semi-colon)

# pass rule in first function
def first(rule):
    global rules, nonterm_userdef, \
        term_userdef, diction, firsts

    # recursion base condition
    # (for terminal or epsilon)
    if len(rule) != 0 and (rule is not None):
        if rule[0] in term_userdef:
            return rule[0]
        elif rule[0] == '#':
            return '#'

    # condition for Non-Terminals
    if len(rule) != 0:
        if rule[0] in list(diction.keys()):

            # fres temporary list of result
            fres = []
            rhs_rules = diction[rule[0]]

            # call first on each rule of RHS
            # fetched (& take union)
            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 no epsilon in result
        # - received return fres
        if '#' not in fres:
            return fres
        else:

            # apply epsilon
            # rule => f(ABC)=f(A)-{e} U f(BC)
            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
```

```
                # if result is not already returned
                # - control reaches here
                # lastly if eplison still persists
                # - keep it in result of first
                fres.append('#')
                return fres


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

    # for start symbol return $ (recursion base
case)
    solset = set()
    if nt == start_symbol:
        # return '$'
        solset.add('$')

    # check all occurrences
    # solset - is result of computed 'follow' so far

    # For input, check in all rules
    for curNT in diction:
        rhs = diction[curNT]
```

```
        # go for all productions of NT
        for subrule in rhs:
            if nt in subrule:

                # call for all occurrences on
                # - non-terminal in subrule
                while nt in subrule:
                    index_nt = subrule.index(nt)
                    subrule = subrule[index_nt +
1:]

                    # empty condition - call follow
on LHS
                    if len(subrule) != 0:

                        # compute first if symbols
on
                        # - RHS of target Non-
Terminal exists
                        res = first(subrule)

                        # if epsilon in result apply
rule
                        # - (A->aBX)- follow of -
                        # - follow(B)=(first(X)-{ep})
U follow(A)
                        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:

                    # when nothing in RHS, go
circular
                    # - and take follow of LHS
                    # only if (NT in
LHS)!=curNT
                    if nt != curNT:
                        res = follow(curNT)

                # add follow result in set form
                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 createParseTable(statesDict, stateMap, T,
NT):
    global separatedRulesList, diction

    # create rows and cols
    rows = list(statesDict.keys())
    cols = T+['$']+NT

    # create empty table
    Table = []
    tempRow = []
    for y in range(len(cols)):
        tempRow.append('')
    for x in range(len(rows)):
        Table.append(copy.deepcopy(tempRow))

    # make shift and GOTO entries in table
    for entry in stateMap:
        state = entry[0]
        symbol = entry[1]
        # get index
        a = rows.index(state)
```

```
        b = cols.index(symbol)
        if symbol in NT:
            Table[a][b] = Table[a][b]\
                + f"{stateMap[entry]} "
        elif symbol in T:
            Table[a][b] = Table[a][b]\
                + f"S{stateMap[entry]} "

    # start REDUCE procedure

    # number the separated rules
    numbered = {}
    key_count = 0
    for rule in separatedRulesList:
        tempRule = copy.deepcopy(rule)
        tempRule[1].remove('.')
        numbered[key_count] = tempRule
        key_count += 1

    # start REDUCE procedure
    # format for follow computation
    addedR = f"{separatedRulesList[0][0]} -> " \
        f"{separatedRulesList[0][1][1]}"
    rules.insert(0, addedR)
    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

    # find 'handle' items and calculate follow.
    for stateno in statesDict:
        for rule in statesDict[stateno]:
            if rule[1][-1] == '.':

                # match the item
                temp2 = copy.deepcopy(rule)
                temp2[1].remove('.')
                for key in numbered:
                    if numbered[key] == temp2:

                        # put Rn in those ACTION
symbol columns,
                        # who are in the follow of
                        # LHS of current Item.
                        follow_result =
follow(rule[0])
```

```
                    for col in follow_result:
                        index = cols.index(col)
                        if key == 0:

    Table[stateno][index] = "Accept"
                        else:

    Table[stateno][index] =\

    Table[stateno][index]+f"R{key} "

    # printing table
    print("\nSLR(1) parsing table:\n")
    frmt = "{:>8}" * len(cols)
    print("  ", frmt.format(*cols), "\n")
    ptr = 0
    j = 0
    for y in Table:
        frmt1 = "{:>8}" * len(y)
        print(f"{{:>3}} {frmt1.format(*y)}"
            .format('I'+str(j)))
        j += 1

def printResult(rules):
    for rule in rules:
        print(f"{rule[0]} ->"
            f" {' '.join(rule[1])}")
```

```
def printAllGOTO(diction):
    for itr in diction:
        print(f"GOTO ( I{itr[0]} ,"
            f" {itr[1]} ) = I{stateMap[itr]}")

# *** MAIN *** - Driver Code

# uncomment any rules set to test code
# follow given format to add -
# user defined grammar rule set
# rules section - *START*

# example sample set 01
rules = ["E -> E + T | T",
        "T -> T * F | F",
        "F -> ( E ) | id"
        ]
nonterm_userdef = ['E', 'T', 'F']
term_userdef = ['id', '+', '*', '(', ')']
start_symbol = nonterm_userdef[0]

# example sample set 02
# rules = ["S -> a X d | b Y d | a Y e | b X e",
#         "X -> c",
#         "Y -> c"
#         ]
# nonterm_userdef = ['S','X','Y']
# term_userdef = ['a','b','c','d','e']
```

```
# start_symbol = nonterm_userdef[0]

# rules section - *END*
print("\nOriginal grammar input:\n")
for y in rules:
    print(y)

# print processed rules
print("\nGrammar after Augmentation: \n")
separatedRulesList = \
    grammarAugmentation(rules,
                        nonterm_userdef,
                        start_symbol)
printResult(separatedRulesList)

# find closure
start_symbol = separatedRulesList[0][0]
print("\nCalculated closure: I0\n")
I0 = findClosure(0, start_symbol)
printResult(I0)

# use statesDict to store the states
# use stateMap to store GOTOs
statesDict = {}
stateMap = {}

# add first state to statesDict
# and maintain stateCount
```

```
# - for newState generation
statesDict[0] = I0
stateCount = 0

# computing states by GOTO
generateStates(statesDict)

# print goto states
print("\nStates Generated: \n")
for st in statesDict:
    print(f"State = I{st}")
    printResult(statesDict[st])
    print()

print("Result of GOTO computation:\n")
printAllGOTO(stateMap)

# "follow computation" for making REDUCE
entries
diction = {}

# call createParseTable function
createParseTable(statesDict, stateMap,
                 term_userdef,
                 nonterm_userdef)
```

output-

```
Original grammar input:

E -> E + T | T
T -> T * F | F
F -> ( E ) | id

Grammar after Augmentation:

E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

Calculated closure: I0

E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

States Generated:

State = I0
E' -> . E
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

State = I1
E' -> E .
E -> E . + T
```

```
State = I2
E -> T .
T -> T . * F

State = I3
T -> F .

State = I4
F -> ( . E )
E -> . E + T
E -> . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

State = I5
F -> id .

State = I6
E -> E + . T
T -> . T * F
T -> . F
F -> . ( E )
F -> . id

State = I7
T -> T * . F
F -> . ( E )
F -> . id

State = I8
F -> ( E . )
E -> E . + T

State = I9
E -> E + T .
T -> T . * F

State = I10
T -> T * F .

State = I11
F -> ( E ) .

Result of GOTO computation:

GOTO ( I0 , E ) = I1
GOTO ( I0 , T ) = I2
GOTO ( I0 , F ) = I3
GOTO ( I0 , ( ) = I4
GOTO ( I0 , id ) = I5
GOTO ( I1 , + ) = I6
GOTO ( I2 , * ) = I7
GOTO ( I4 , E ) = I8
GOTO ( I4 , T ) = I2
```

```
Result of GOTO computation:

GOTO ( I0 , E ) = I1
GOTO ( I0 , T ) = I2
GOTO ( I0 , F ) = I3
GOTO ( I0 , ( ) = I4
GOTO ( I0 , id ) = I5
GOTO ( I1 , + ) = I6
GOTO ( I2 , * ) = I7
GOTO ( I4 , E ) = I8
GOTO ( I4 , T ) = I2
GOTO ( I4 , F ) = I3
GOTO ( I4 , ( ) = I4
GOTO ( I4 , id ) = I5
GOTO ( I6 , T ) = I9
GOTO ( I6 , F ) = I3
GOTO ( I6 , ( ) = I4
GOTO ( I6 , id ) = I5
GOTO ( I7 , F ) = I10
GOTO ( I7 , ( ) = I4
GOTO ( I7 , id ) = I5
GOTO ( I8 , ) ) = I11
GOTO ( I8 , + ) = I6
GOTO ( I9 , * ) = I7

SLR(1) parsing table:
```

	id	+	*	(	)	$	E	T	F
I0	S5			S4			1	2	3
I1		S6				Accept			
I2		R2	S7		R2	R2			
I3		R4	R4		R4	R4			
I4	S5			S4			8	2	3
I5		R6	R6		R6	R6			
I6	S5			S4				9	3
I7	S5			S4					10
I8		S6			S11				
I9		R1	S7		R1	R1			
I10		R3	R3		R3	R3			
I11		R5	R5		R5	R5			

```
iiitm@iiit-manipur-director:~$
```