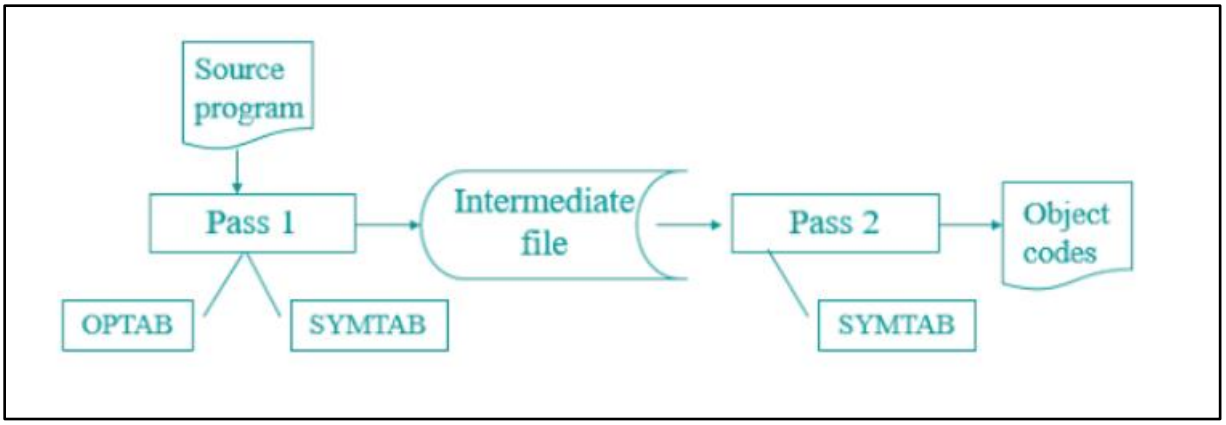
System Software (CS306)

Assignment - 5

U19CS012

1) Write a C Program to Implement **Two Pass Assembler**.



PASS-1

Code:

```cpp
// PASS 1 Of Two-Pass Assembler

#include <bits/stdc++.h>
using namespace std;

// [U19CS012] BHAGYA VINOD RANA

// To store mnemonics of the opcodes
// Operational Table.
struct OPtab
{
    string opcode;
    string mclass;
    string mnemonic;
};

// Hard-coding the class and mnemonic for respective opcode
struct OPtab optab[18] = {
    {"STOP", "IS", "00"},
    {"ADD", "IS", "01"},
    {"SUB", "IS", "02"},
    {"MULT", "IS", "03"},
    {"MOVER", "IS", "04"},
    {"MOVEM", "IS", "05"},
    {"COMP", "IS", "06"},
```

```
    {"BC", "IS", "07"},
    {"DIV", "IS", "08"},
    {"READ", "IS", "09"},
    {"PRINT", "IS", "10"},
    {"START", "AD", "01"},
    {"END", "AD", "02"},
    {"ORIGIN", "AD", "03"},
    {"EQU", "AD", "04"},
    {"LTORG", "AD", "05"},
    {"DC", "DL", "01"},
    {"DS", "DL", "02"}};

// Function to fetch the opcode entry
int getOP(string s);

// Function to fetch the register code
int getRegID(string s);

// Function to fetch conditional code
int getConditionCode(string s);

// To store Symbol Table output
struct symTable
{
    int no;
    string sname;
    string addr;
};

struct symTable ST[10];

// Function to check presence of a particular 'symbol'
bool presentST(string s);

// Function to fetch the symbol entry
int getSymID(string s);

// To store Literal Table output
struct litTable
{
    int no;
    string lname;
    string addr;
};

struct litTable LT[10];

// Function to check presence of a particular 'literal'
bool presentLT(string s);
```

```cpp
// Function to fetch the literal entry
int getLitID(string s);

// To store Pool Table output
struct poolTable
{
    int no;
    string lno;
};

struct poolTable PT[10];

int main()
{
    ifstream fin;

    // input assembly code file
    // empty space (eg. no operand2 / no label) is denoted by "NAN"
    fin.open("source.asm");

    ofstream ic, st, lt, pt;

    // Saving the output of pass1 into pass2 source code directory.
    // Since it will be the input for pass2.cpp
    // The paths may change accordingly

    ic.open("ic.txt");
    st.open("symtable.txt");
    lt.open("littable.txt");
    pt.open("pooltable.txt");

    string label, opcode, op1, op2;

    int scnt = 0, lcnt = 0, nlcnt = 0, pcnt = 0, LC = 0;

    cout << "\n ~x~x~x~x~ ASSEMBLER PASS-1 OUTPUT ~x~x~x~x~" << endl;

    cout << "\n <LABEL\tOPCODE\tOP1\tOP2\tLC\tINTERMEDIATE CODE>" << endl;

    while (!fin.eof())
    {
        // reading the assembly code line by line
        fin >> label >> opcode >> op1 >> op2;

        int id;
        // IC - Intermediate code, lc - LC processing,
        string IC, lc;

        // fetch the opcode entry
        id = getOP(opcode);
```

```
        IC = "(" + optab[id].mclass + "," + optab[id].mnemonic + ") ";

        // Individual cases for Assembly Directives (AD) - START, END, ORIGIN, EQU, LTORG
        // no LC processing for AD so lc = "---"

        if (opcode == "START")
        {
            lc = "---";
            if (op1 != "NAN")
            {
                LC = stoi(op1);
                IC += "(C," + op1 + ") NAN";
            }
        }

        if (opcode == "EQU")
        {
            lc = "---";
            IC += " NAN NAN";
            if (presentST(label))
            {
                ST[getSymID(label)].addr = ST[getSymID(op1)].addr;
            }
            else
            {
                ST[scnt].no = scnt + 1;
                ST[scnt].sname = label;
                ST[scnt].addr = ST[getSymID(op1)].addr;
                scnt++;
            }
        }
        else if (label != "NAN")
        {
            if (presentST(label))
            {
                ST[getSymID(label)].addr = to_string(LC);
            }
            else
            {
                ST[scnt].no = scnt + 1;
                ST[scnt].sname = label;
                ST[scnt].addr = to_string(LC);
                scnt++;
            }
        }

        if (opcode == "ORIGIN")
        {
            string token1, token2;
```

```
            char op;
            stringstream ss(op1);
            size_t found = op1.find('+');

            if (found != string::npos)
            {
                op = '+';
            }
            else
            {
                op = '-';
            }
            getline(ss, token1, op);
            getline(ss, token2, op);
            lc = "---";
            if (op == '+')
            {
                LC = stoi(ST[getSymID(token1)].addr) + stoi(token2);
                IC += "(S,0" + to_string(ST[getSymID(token1)].no) + ")+" + token2 + "NAN ";
            }
            else
            {
                LC = stoi(ST[getSymID(token1)].addr) - stoi(token2);
                IC += "(S,0" + to_string(ST[getSymID(token1)].no) + ")-" + token2 + "NAN ";
            }
        }

        if (opcode == "LTORG")
        {
            cout << " " << label << "\t" << opcode << "\t" << op1 << "\t" << op2 << "\t";
            for (int i = lcnt - nlcnt; i < lcnt; ++i)
            {
                lc = to_string(LC);
                IC = "(DL,01) (C,";
                string c(1, LT[i].lname[2]);
                IC += c + ")    NAN";
                LT[i].addr = to_string(LC);
                LC++;
                if (i < lcnt - 1)
                {
                    cout << lc << "\t" << IC << "\n\t\t\t\t";
                }
                else
                {
                    cout << lc << "\t" << IC << endl;
                }
                ic << lc << "\t" << IC << endl;
            }
            // managing pool table in LTORG
            PT[pcnt].lno = "#" + to_string(LT[lcnt - nlcnt].no);
```

```
            PT[pcnt].no = pcnt + 1;
            pcnt++;

            nlcnt = 0;
            continue;
        }

        if (opcode == "END")
        {
            lc = "---";
            IC += " NAN NAN";
            cout << " " << label << "\t" << opcode << "\t" << op1 << "\t" << op2 << "\t" <<
lc << "\t" << IC << endl;

            ic << lc << "\t" << IC << endl;

            if (nlcnt)
            {
                for (int i = lcnt - nlcnt; i < lcnt; ++i)
                {
                    lc = to_string(LC);
                    IC = "(DL,01) (C,";
                    string c(1, LT[i].lname[2]);
                    IC += c + ")    NAN";
                    LT[i].addr = to_string(LC);
                    LC++;
                    cout << "\t\t\t\t" << lc << "\t" << IC << endl;
                    ic << lc << "\t" << IC << endl;
                }
            }

            // managing pool table after END (if any literals are left)
            PT[pcnt].lno = "#" + to_string(LT[lcnt - nlcnt].no);
            PT[pcnt].no = pcnt + 1;
            pcnt++;

            break;
        }

        // Declarative Statements (DL)
        if (opcode == "DC" || opcode == "DS")
        {
            lc = to_string(LC);
            if (opcode == "DS")
            {
                IC += "(C," + op1 + ")  NAN";
                LC += stoi(op1);
            }
            else
            {
```

```
                string c(1, op1[1]);
                IC += "(C," + c + ")";
                LC++;
            }
        }

        // if not AD or DL then, Imperative Statements (IS)
        if (opcode != "START" && opcode != "END" && opcode != "ORIGIN" && opcode != "EQU" &&
opcode != "LTORG" && opcode != "DC" && opcode != "DS")
        {
            if (op2 == "NAN")
            {
                if (op1 == "NAN")
                {
                    lc = to_string(LC);
                    LC++;
                    IC += " NAN NAN";
                }
                else
                {
                    if (presentST(op1))
                    {
                        IC += "(S,0" + to_string(ST[getSymID(op1)].no) + ")";
                        lc = to_string(LC);
                        LC++;
                    }
                    else
                    {
                        ST[scnt].no = scnt + 1;
                        ST[scnt].sname = op1;
                        scnt++;
                        IC += "(S,0" + to_string(ST[getSymID(op1)].no) + ")";
                        lc = to_string(LC);
                        LC++;
                    }
                }
            }
            else
            {
                if (opcode == "BC")
                {
                    IC += "(" + to_string(getConditionCode(op1)) + ")   ";
                }
                else
                {
                    IC += "(" + to_string(getRegID(op1)) + ")   ";
                }
                if (op2[0] == '=')
                {
                    // operand2 is a literal
```

```
                    LT[lcnt].no = lcnt + 1;
                    LT[lcnt].lname = op2;
                    lcnt++;
                    nlcnt++;
                    IC += "(L,0" + to_string(LT[getLitID(op2)].no) + ")";
                }
                else
                {
                    // operand2 is a symbol
                    if (presentST(op2))
                    {
                        IC += "(S,0" + to_string(ST[getSymID(op2)].no) + ")";
                    }
                    else
                    {
                        ST[scnt].no = scnt + 1;
                        ST[scnt].sname = op2;
                        scnt++;
                        IC += "(S,0" + to_string(ST[getSymID(op2)].no) + ")";
                    }
                }
                lc = to_string(LC);
                LC++;
            }
        }

        // console output
        cout << " " << label << "\t" << opcode << "\t" << op1 << "\t" << op2 << "\t" << lc <<
"\t" << IC << endl;
        ic << lc << "\t" << IC << endl;
    }

    cout << "\n-----------------------------------------------------------------------" <<
endl;
    cout << " ~x~x~x~ SYMBOL TABLE ~x~x~x~" << endl;
    cout << "\n <NO.\tSYMBOL\tADDRESS>" << endl;
    for (int i = 0; i < scnt; ++i)
    {
        cout << " " << ST[i].no << "\t " << ST[i].sname << "\t " << ST[i].addr << endl;
        st << ST[i].no << "\t " << ST[i].sname << "\t " << ST[i].addr << endl;
    }
    cout << "\n-----------------------------------------------------------------------" <<
endl;
    cout << " ~x~x~x~ LITERAL TABLE ~x~x~x~" << endl;
    cout << "\n <NO.\tLITERAL\tADDRESS>" << endl;
    for (int i = 0; i < lcnt; ++i)
    {
        cout << " " << LT[i].no << "\t " << LT[i].lname << "\t " << LT[i].addr << endl;
        lt << LT[i].no << "\t " << LT[i].lname << "\t " << LT[i].addr << endl;
    }
```

```
    cout << "\n-----------------------------------------------------------------------" <<
endl;
    cout << " ~x~x~x~ POOL TABLE ~x~x~x~" << endl;
    cout << "\n <NO.\tLITERAL_NO.>" << endl;
    for (int i = 0; i < pcnt; ++i)
    {
        cout << " " << PT[i].no << "\t  " << PT[i].lno << endl;
        pt << PT[i].no << "\t   " << PT[i].lno << endl;
    }

    return 0;
}

// Function to fetch the opcode entry
int getOP(string s)
{
    for (int i = 0; i < 18; ++i)
    {
        if (optab[i].opcode == s)
            return i;
    }
    return -1;
}

// Function to fetch the register code
int getRegID(string s)
{
    if (s == "AREG")
    {
        return 1;
    }
    else if (s == "BREG")
    {
        return 2;
    }
    else if (s == "CREG")
    {
        return 3;
    }
    else if (s == "DREG")
    {
        return 4;
    }
    else
    {
        return -1;
    }
}

// Function to fetch conditional code
```

```
int getConditionCode(string s)
{
    if (s == "LT")
    {
        return 1;
    }
    else if (s == "LE")
    {
        return 2;
    }
    else if (s == "EQ")
    {
        return 3;
    }
    else if (s == "GT")
    {
        return 4;
    }
    else if (s == "GE")
    {
        return 5;
    }
    else if (s == "ANY")
    {
        return 6;
    }
    else
    {
        return -1;
    }
}

// Function to check presence of a particular 'symbol'
bool presentST(string s)
{
    for (int i = 0; i < 10; ++i)
    {
        if (ST[i].sname == s)
        {
            return true;
        }
    }
    return false;
}

// Function to fetch the symbol entry
int getSymID(string s)
{
    for (int i = 0; i < 10; ++i)
    {
```

```
        if (ST[i].sname == s)
        {
            return i;
        }
    }
    return -1;
}

// Function to check presence of a particular 'literal'
bool presentLT(string s)
{
    for (int i = 0; i < 10; ++i)
    {
        if (LT[i].lname == s)
        {
            return true;
        }
    }
    return false;
}

// Function to fetch the literal entry
int getLitID(string s)
{
    for (int i = 0; i < 10; ++i)
    {
        if (LT[i].lname == s)
        {
            return i;
        }
    }
    return -1;
}
```

PASS-2

Code:

```
// PASS 2 Of Two-Pass Assembler

#include <bits/stdc++.h>
using namespace std;

// [U19CS012] BHAGYA VINOD RANA

// Function to fetch symbol/literal address from symbol_table or literal_table
string table(ifstream &fin, string n)
{
    string no, name, addr;
    while (fin >> no >> name >> addr)
    {
        if (no == n)
        {
            fin.seekg(0, ios::beg);
            return addr;
        }
    }
    fin.seekg(0, ios::beg);
    return "NAN";
}

int main()
{

    ifstream ic, st, lt;
    // pass1 output files as input to pass2
    ic.open("ic.txt");
    st.open("symtable.txt");
    lt.open("littable.txt");
    // generate file output of machine code
    ofstream mc;
    mc.open("machine_code.txt");

    string lc, ic1, ic2, ic3;
    cout << "\n -- ASSEMBLER PASS-2 OUTPUT --" << endl;
    cout << "\n LC\t <INTERMEDIATE CODE>\t\t\tLC\t <MACHINE CODE>" << endl;

    // reading input file line by line
    while (ic >> lc >> ic1 >> ic2 >> ic3)
    {
        // machine code
        string MC;

        // no machine code for AD and DL,02 i.e. DS opcodes
```

```
        if (ic1.substr(1, 2) == "AD" || (ic1.substr(1, 2) == "DL" && ic1.substr(4, 2) ==
"02"))
        {

            MC = " -No Machine Code-";
        }
        // if opcode is DL i.e. DL,01 then display constant value at the place of memory
operand
        else if (ic1.substr(1, 2) == "DL" && ic1.substr(4, 2) == "01")
        {
            MC = "00\t0\t00" + ic2.substr(3, 1);
        }
        else
        {
            // IS opcode
            if (ic1 == "(IS,00)")
            { // specifically for STOP
                MC = ic1.substr(4, 2) + "\t0\t000";
            }
            else if (ic2.substr(1, 1) == "S")
            { // if opcode in pass1 was ORIGIN
                MC = ic1.substr(4, 2) + "\t0\t" + table(st, ic2.substr(4, 1));
            }
            else
            {
                if (ic3.substr(1, 1) == "S")
                    // for symbols
                    MC = ic1.substr(4, 2) + "\t" + ic2.substr(1, 1) + "\t" + table(st,
ic3.substr(4, 1));
                else
                    // for literals
                    MC = ic1.substr(4, 2) + "\t" + ic2.substr(1, 1) + "\t" + table(lt,
ic3.substr(4, 1));
            }
        }
        if (ic1 == "(AD,03)")
        {
            // just for console output display format
            cout << " " << lc << "\t" << ic1 << "\t" << ic2 << " " << ic3 << "\t\t\t" << lc
<< "\t" << MC << endl;
            mc << lc << "\t" << MC << endl;
            continue;
        }
        // console output
        cout << " " << lc << "\t" << ic1 << "\t" << ic2 << "\t " << ic3 << "\t\t\t" << lc
             << "\t" << MC << endl;
        mc << lc << "\t" << MC << endl;
    }
    return 0;
}
```

PASS-1 I/O

INPUT	OUTPUT
source.asm->assembly language code	**ic.txt** containing intermediate code
Prebuilt OPTAB	**littable.txt** containing literal table
	symtable.txt containing symbol table
	pooltable.txt containing pool table

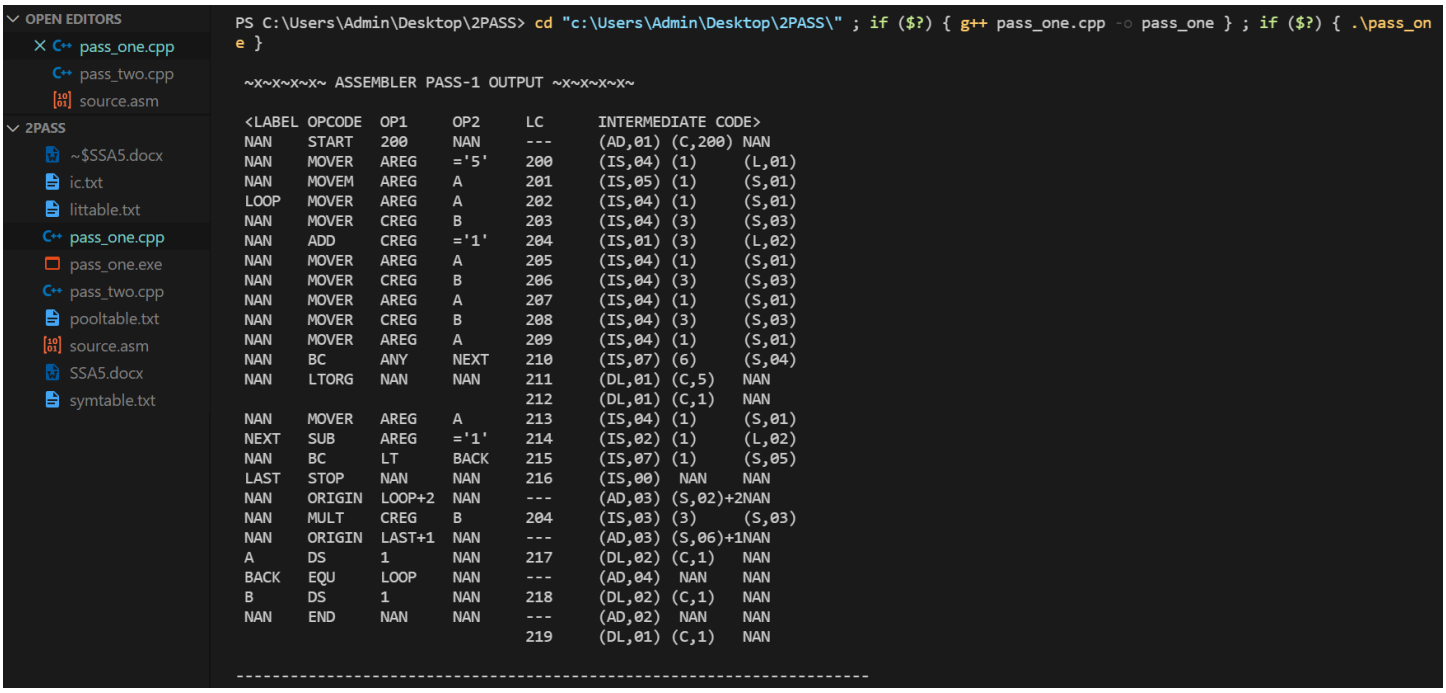
PASS-2 I/O

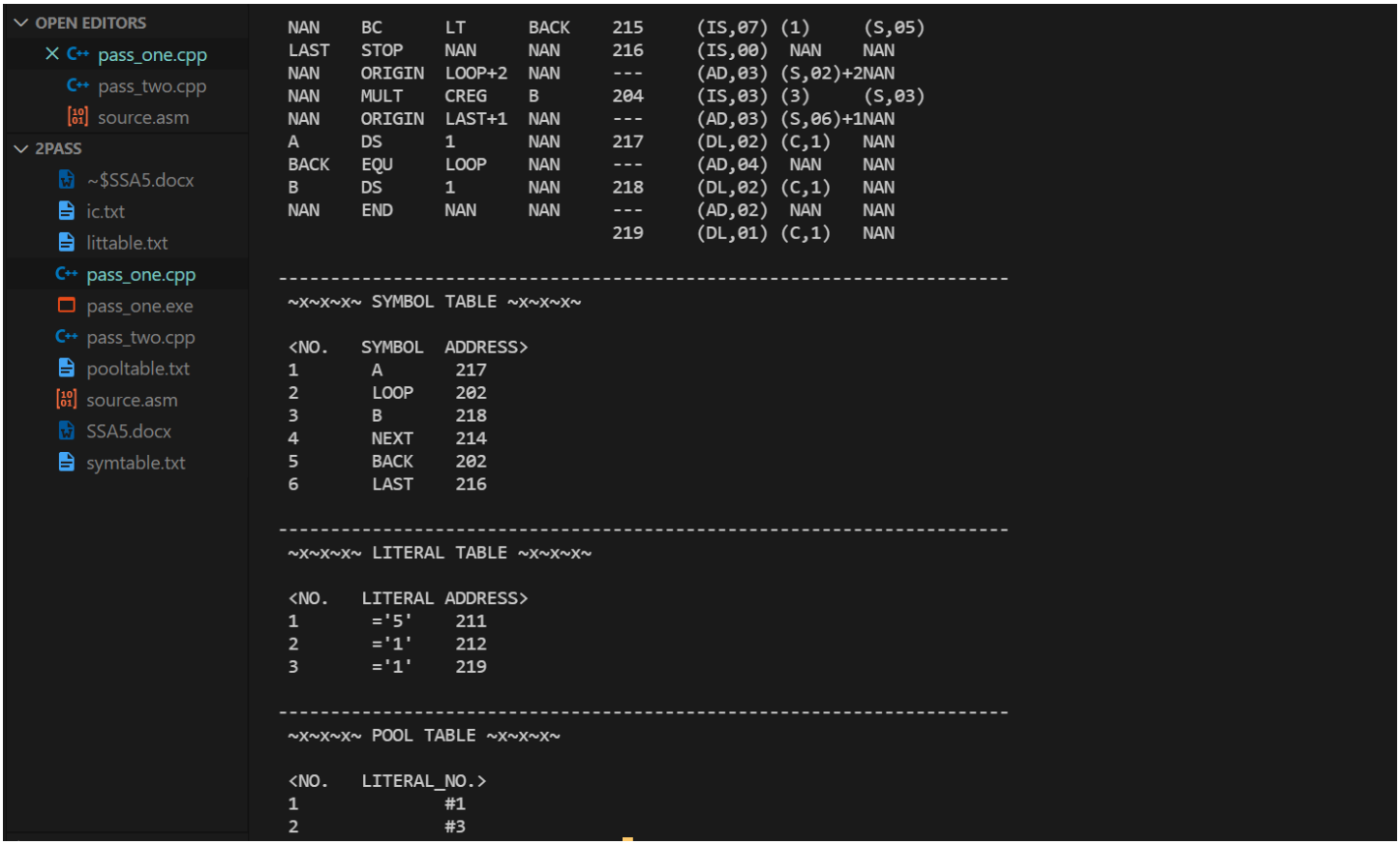
INPUT	OUTPUT
ic.txt **containing intermediate code**	**machine_code.txt** containing machine code.
littable.txt **containing literal table**	
symtable.txt **containing symbol table**	

How to execute?

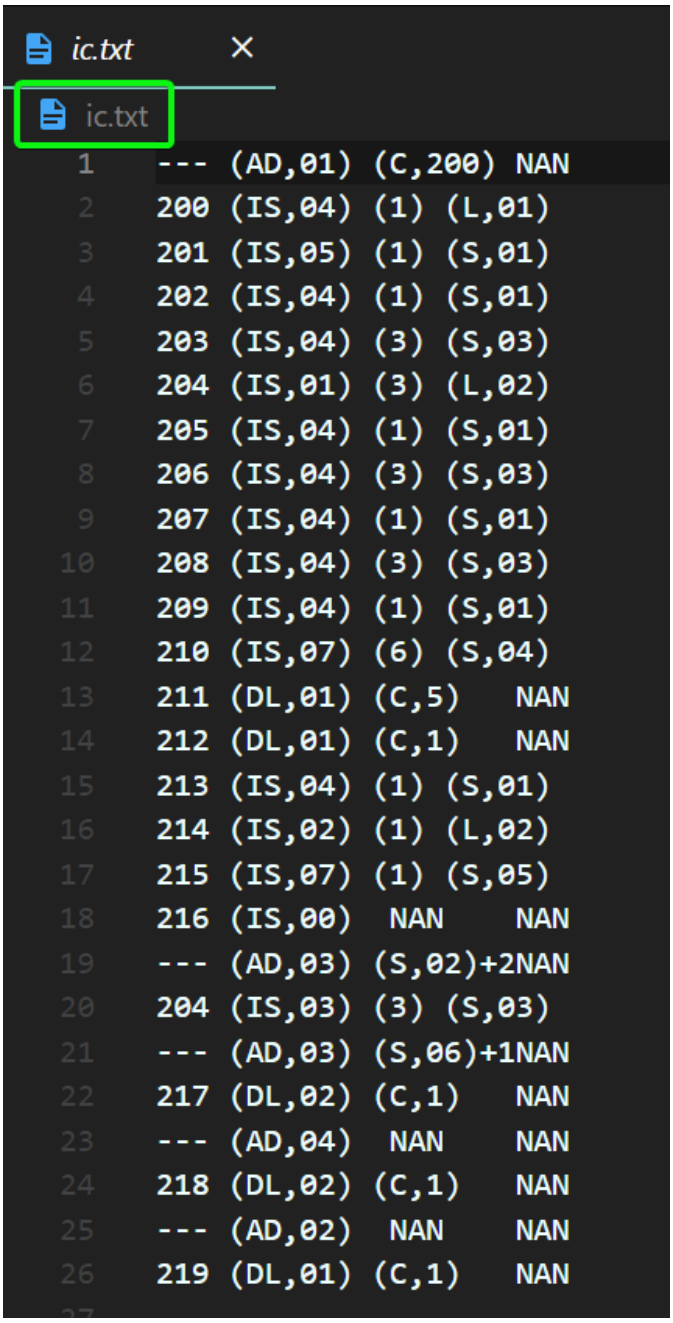
1. Compile and execute **pass_one.cpp** source code by providing **source.asm** as input (save it in the same folder as pass1.cpp).
2. The output of this file will be shown on terminal as well as saved in the files name "**littable.txt**", "**symtable.txt**", "**ic.txt**", "**pooltable.txt**".
3. Now, compile and execute **pass_two.cpp** source code. It will take ic.txt, littable.txt, symtable.txt as an **input**.
4. The output will be saved in "**machine_code.txt**" file.

After Executing PASS-1

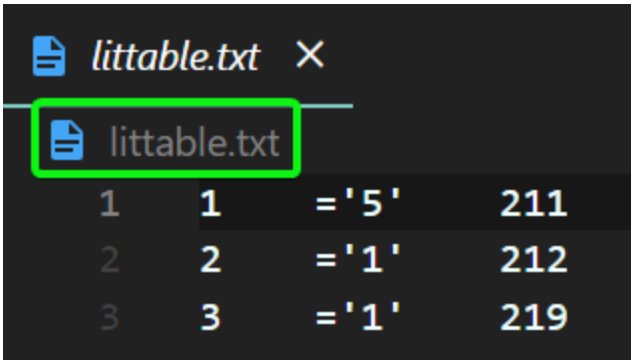




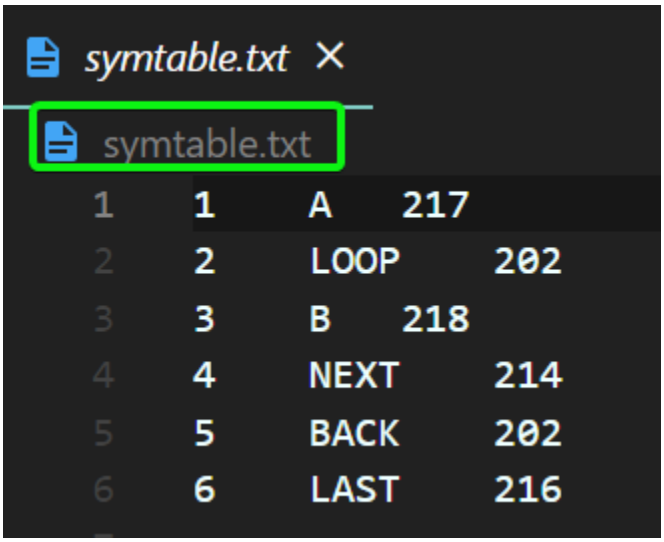
ic.txt



littable.txt



symtable.txt



pooltable.txt

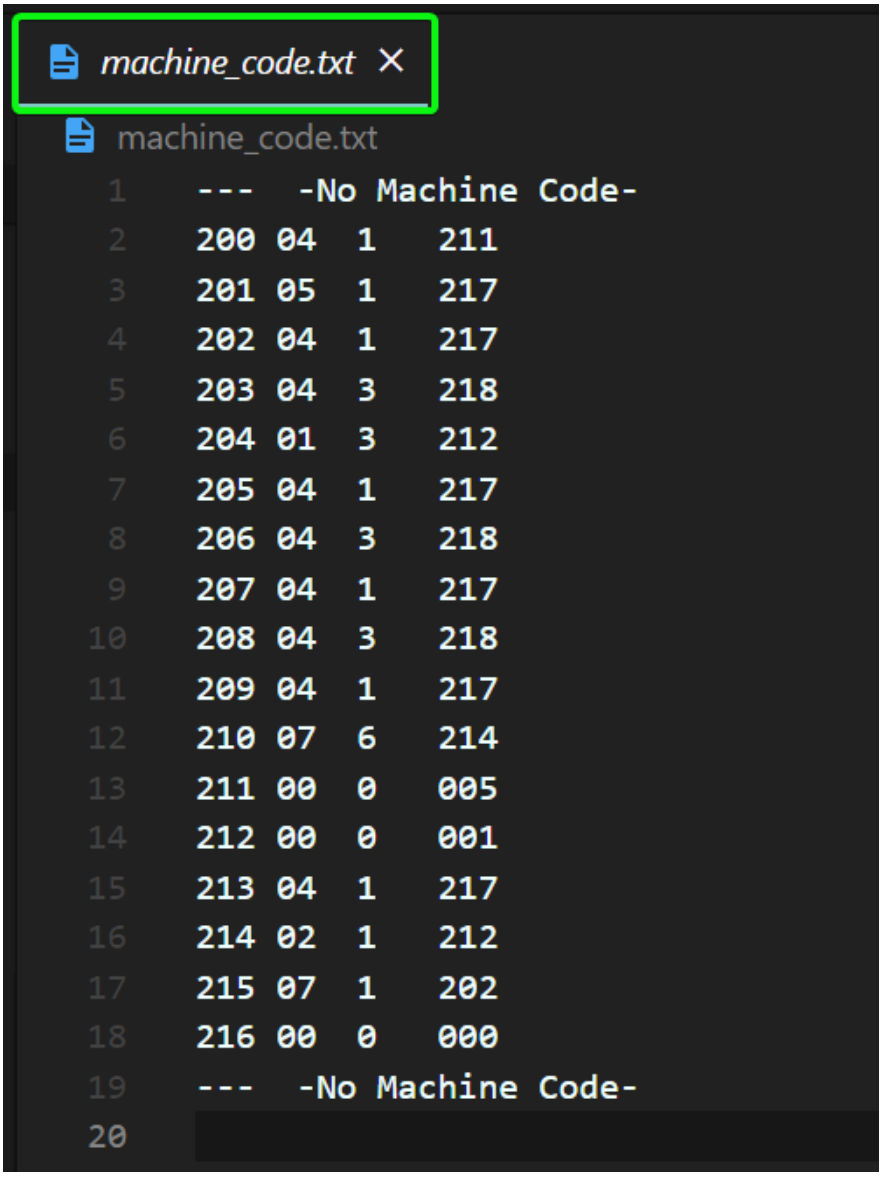
After Executing PASS-2

```
PS C:\Users\Admin\Desktop\2PASS> cd "c:\Users\Admin\Desktop\2PASS\" ; if ($?) { g++ pass_two.cpp -o pass_two } ; if ($?) { .\pass_two }

 -- ASSEMBLER PASS-2 OUTPUT --

 LC      <INTERMEDIATE CODE>                LC       <MACHINE CODE>
 ---    (AD,01) (C,200)  NAN                ---      -No Machine Code-
 200    (IS,04) (1)      (L,01)             200     04      1       211
 201    (IS,05) (1)      (S,01)             201     05      1       217
 202    (IS,04) (1)      (S,01)             202     04      1       217
 203    (IS,04) (3)      (S,03)             203     04      3       218
 204    (IS,01) (3)      (L,02)             204     01      3       212
 205    (IS,04) (1)      (S,01)             205     04      1       217
 206    (IS,04) (3)      (S,03)             206     04      3       218
 207    (IS,04) (1)      (S,01)             207     04      1       217
 208    (IS,04) (3)      (S,03)             208     04      3       218
 209    (IS,04) (1)      (S,01)             209     04      1       217
 210    (IS,07) (6)      (S,04)             210     07      6       214
 211    (DL,01) (C,5)    NAN                211     00      0       005
 212    (DL,01) (C,1)    NAN                212     00      0       001
 213    (IS,04) (1)      (S,01)             213     04      1       217
 214    (IS,02) (1)      (L,02)             214     02      1       212
 215    (IS,07) (1)      (S,05)             215     07      1       202
 216    (IS,00) NAN      NAN                216     00      0       000
 ---    (AD,03) (S,02)+2NAN 204             ---      -No Machine Code-
PS C:\Users\Admin\Desktop\2PASS>
```

machine_code.txt



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