Date: 8 Sept, 2021.

Assignment number : A-01

1) **Title**: Design suitable data structure and implement Pass-I assembler for pseudo-machine. Implementation should consist a few instruction from each category and assembler dis

2) **Software / Hardware requirement**:

* **Software requirements**:

1) Java Development kit.
2) Integrated Development Environment OR.
3) Notepad ++.

* **Hardware Requirements**.

1) Computer System
   Processor : i5 9th Gen
   Ram : 8 GB
2) I/O Peripherals like keyboard & Mouse.
3) Monitor : 720p / 1080p FHD/IPS.

3) **Learning Objective**:

1) To understand the working of pass-I assembler.
2) To use appropriate data structure to solve given problem.
3) To apply programming knowledge and skills to find optimum solution for given problem.

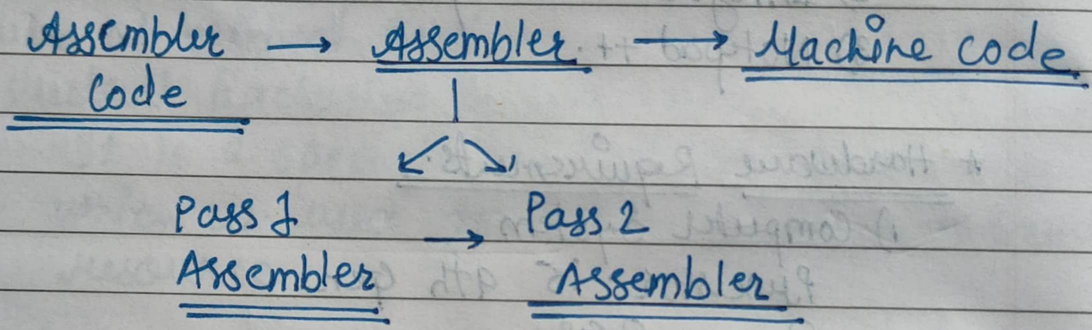
4) **Learning Outcome**:

1) Understood the working of Pass-I assembler.
2) Used appropriate data structure to solve the given problem.

3) Applied programming background and skills to solve given problem.

5] **Concept related Theory:**

Assembler is a program for converting instructions written in low-Level assembly code into relocateable machine code and generating along information for the loader.



It generates instructions by evaluating the mnemonics in operations field and find the value of symbol and literals to produce machine code. Now, if assembler do this in one scan then it is called as single pass assembler, otherwise if it does in multiple scans then called multiple pass assembler.

- Pass 1 assembler:
  1) Defines symbols and literals and remember them in symbol table and literal table respectively
  2) Keep track of location counter.
  3) Process pseudo-operations.

- Pass 2 Assembler.

1) Generates Object Code by converting symbolic op-code into respective numeric op-code.
2) Generate data for literals and look for values of symbols.

Opcode

- called mnemonics operation code. They're used to specify operation.
ex. add, sub, mul, etc.

Assembly statements:

An assembly program consists of three kinds of statement

1) Imperative statements: Specifies an operation to be performed.
2) Declarative:
DS is declared storage reserves area of memory and associates name with them.
DC is declare constant - constructs memory word containing constants.
3) Assembler directives: These are the instruction to the assembler and not to the machine. These are some time called pseudo code operations.
eg 1) START
2) END
3) ORIGIN.

Forward reference :

The reference to an entity that precedes its defination in the program is called forward reference. An example is:

```
:
:
:
CALL JUMP
:
:
JUMP:---
:
:
```

Languge processor pass

It is the processing of every statement in a source program or its equivalent representation to perform a language processing function. This is also used during a set of langige processing functions.

Literals

A literal is an operand with the syntax ='<value>'. it differs from a constant because its location cannot be specified in the assembly language program. This help's to ensure that its value is not changed during the execution of a program

E.g

1) ADD AREG ='5'

2) FIVE DC '=5'

6) **Algorithm.**

```
1) Start.
2) loc_cntr = 0 (Default Value) (Location counter)
   pooltab_ptr = 1 ; POOLTAB [1] = 1 ; (points to enty of litTAB)
   littab_ptr = 1; (Points to an entry in POOLTAB)
3) While next readed statement is not END statement.
     a) If a label is present then
          i. this_label = symbol in label field.
          ii. Enter (this_label, loc-cntr) in SYMTAB
     b) If an LTORG statement then
          Allocate memory for literals and increment pooltab_
          ptr.
          i. Process literals LITTAB to allocate memory and
             put the address field. update loc_cntr accordingly
          ii. pooltab_ptr = pooltab_ptr +1 ;
          iii. POOLTAB [pooltab_ptr] = littab_ptr.
     c) If a start or ORIGIN statement the
          Memory allocation process.
          i. loc_cntr = value Specified in operand field;
     d) If an EQU statement then
          update the symbol table entry for Label.
          i. this_address = value specified in <address spec>;
          ii. Correct the symtab entry for this_label to
              (this_label, this_address);
     e) If a declaration statement then
          i. code = code of declaration statement.
```

```
    ii. size = size of memory area required by DC/DS
    iii. loc_cntr = loc_cntr + size;
    iv. Generate IC(DL, code);
  f) If an imperative statement then
    i. Code = Machine opcode from OPTAB.
    ii. loc_cntr = loc_cntr + instructions length from
        OPTAB;
    iii. If operand is a literal then.
          this_literal = literal in operand field;
          ~~tiFTAB~~ LITTAB [littab_ptr] = this_literal;
          littab_ptr = littab_ptr + 1;
        else
          this_entry = SYMTAB entry ~~munber~~ number
          of operand generate IC'(IS, code)(S,
          this_entry);

4) Processing END Statement.
  a) Perform step 3(b) to allocate memory for
     literals.
  b) Generate IC'(AD, 02) IC unit for END.

5) End.
```

7] **Conclusion**

Understood working of pass I assembler and implemented it using programming knowledge.

8] References:

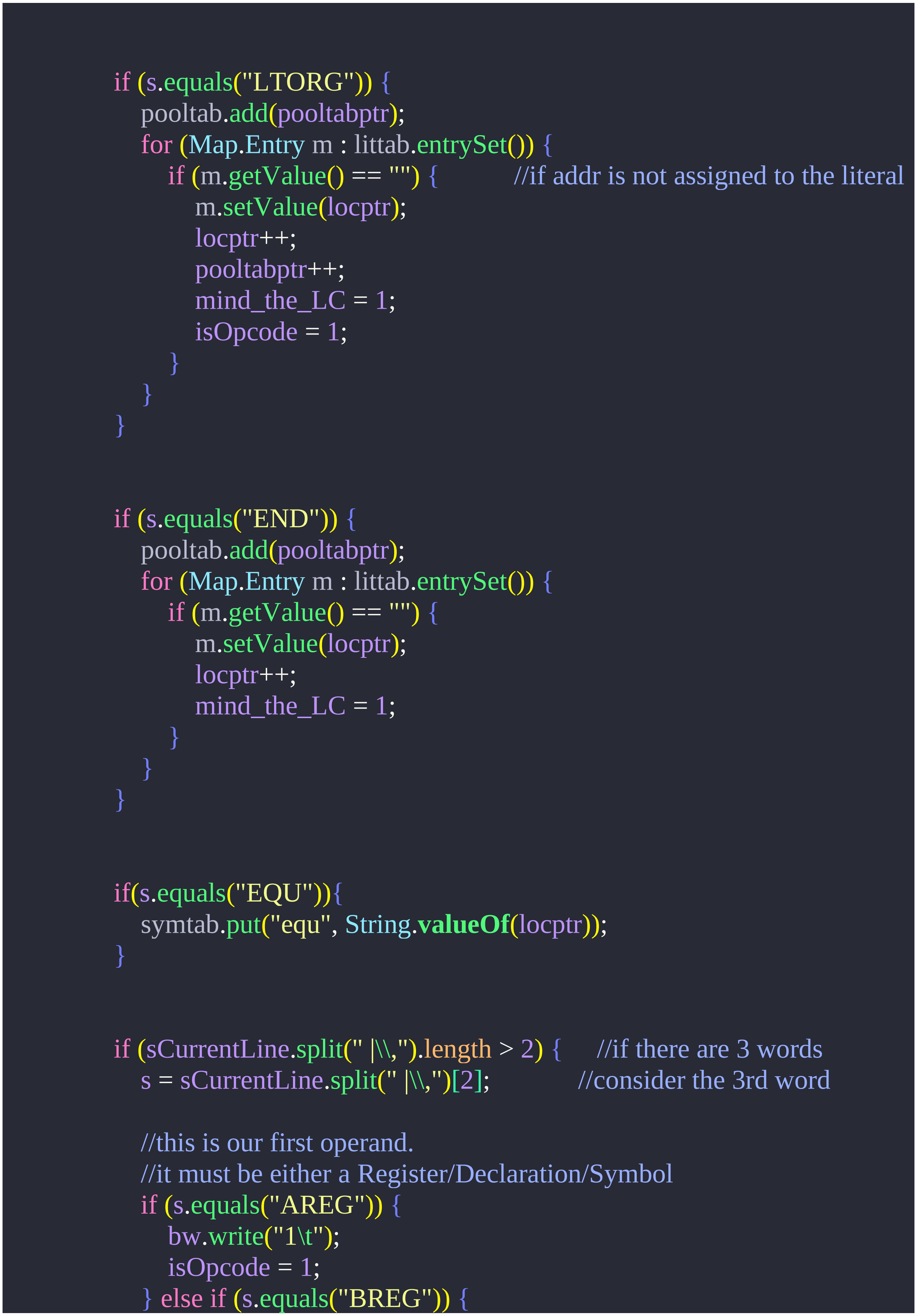
1) geeksforgeeks.
2) youtube.com/pass 1 assembler.
3) wbuthelp.com/chapter_file/2677.pdf.
4) slidetodoc.com/unit-4-unit-3-pushdown-assembler-automata-prof/

- x -

Code:-

```
package com.muthadevs;

import java.io.BufferedReader;
import java.io.*;
import java.io.IOException;
import java.util.*;

public class Main {
    public static void main(String[] args) {

        BufferedReader br = null;
        FileReader fr = null;

        FileWriter fw = null;
        BufferedWriter bw = null;

        try {
            String inputfilename = "E:\\pass1_assembler\\INPUT\\Input.asm";
            fr = new FileReader(inputfilename);
            br = new BufferedReader(fr);

            String OUTPUTFILENAME = "E:\\pass1_assembler\\OUTPUT\\IC.txt";
            fw = new FileWriter(OUTPUTFILENAME);
            bw = new BufferedWriter(fw);

            Hashtable<String, String> is = new Hashtable<String, String>();
            is.put("STOP", "00");
            is.put("ADD", "01");
            is.put("SUB", "02");
            is.put("MULT", "03");
            is.put("MOVER", "04");
            is.put("MOVEM", "05");
            is.put("COMP", "06");
            is.put("BC", "07");
            is.put("DIV", "08");
            is.put("READ", "09");
            is.put("PRINT", "10");

            Hashtable<String, String> dl = new Hashtable<String, String>();
            dl.put("DC", "01");
            dl.put("DS", "02");

            Hashtable<String, String> ad = new Hashtable<String, String>();

            ad.put("START", "01");
            ad.put("END", "02");
            ad.put("ORIGIN", "03");
            ad.put("EQU", "04");
            ad.put("LTORG", "05");

            Hashtable<String, String> symtab = new Hashtable<String, String>();
            Hashtable<String, String> littab = new Hashtable<String, String>();
            ArrayList<Integer> pooltab=new ArrayList<Integer>();

            String sCurrentLine;
            int locptr = 0;
            int litptr = 1;
            int symptr = 1;
            int pooltabptr = 1;

            sCurrentLine = br.readLine();

            String s1 = sCurrentLine.split(" ")[1];
            if (s1.equals("START")) {
                bw.write("AD \t 01 \t");
                String s2 = sCurrentLine.split(" ")[2];
                bw.write("C \t" + s2 + "\n");
                locptr = Integer.parseInt(s2);
            }

            while ((sCurrentLine = br.readLine()) != null) {
                int mind_the_LC = 0;
                String type = null;

                int flag2 = 0;    //checks whether addr is assigned to current symbol

                String s = sCurrentLine.split(" |\\,")[0]; //consider the first word in the
line

                for (Map.Entry m : symtab.entrySet()) {            //allocating addr to
arrived symbols
                if (s.equals(m.getKey())) {
```

```
                m.setValue(locptr);
                flag2 = 1;
            }
        }
        if (s.length() != 0 && flag2 == 0) {      //if current string is not " " or addr
is not assigned,
            //then the current string must be a new symbol.
            symtab.put(s, String.valueOf(locptr));
            symptr++;
        }

        int isOpcode = 0;     //checks whether current word is an opcode or not

        s = sCurrentLine.split(" |\\,")[1];          //consider the second word in the
line

        for (Map.Entry m : is.entrySet()) {
            if (s.equals(m.getKey())) {
                bw.write("IS\t" + m.getValue() + "\t");       //if match found in
imperative stmt
                type = "is";
                isOpcode = 1;
            }
        }


        for (Map.Entry m : ad.entrySet()) {
            if (s.equals(m.getKey())) {
                bw.write("AD\t" + m.getValue() + "\t");       //if match found in
Assembler Directive
                type = "ad";
                isOpcode = 1;
            }
        }
        for (Map.Entry m : dl.entrySet()) {
            if (s.equals(m.getKey())) {
                bw.write("DL\t" + m.getValue() + "\t");       //if match found in
declarative stmt
                type = "dl";
                isOpcode = 1;
            }
        }
```

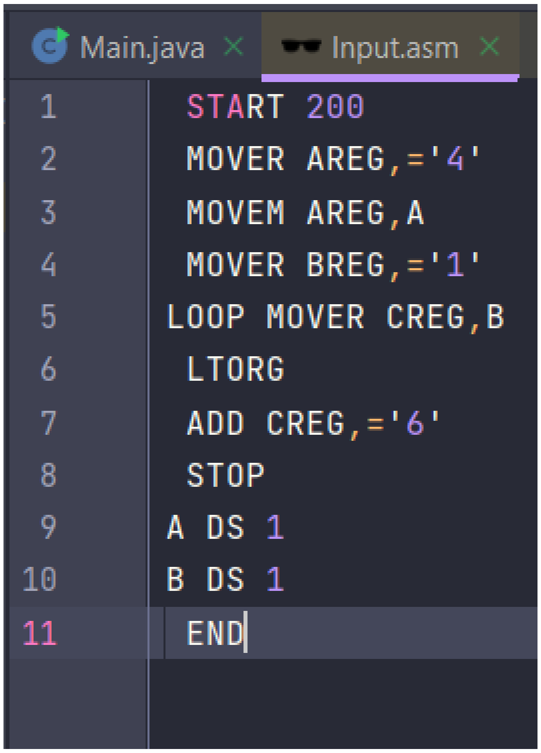


```
if (s.equals("LTORG")) {
    pooltab.add(pooltabptr);
    for (Map.Entry m : littab.entrySet()) {
        if (m.getValue() == "") {           //if addr is not assigned to the literal
            m.setValue(locptr);
            locptr++;
            pooltabptr++;
            mind_the_LC = 1;
            isOpcode = 1;
        }
    }
}


if (s.equals("END")) {
    pooltab.add(pooltabptr);
    for (Map.Entry m : littab.entrySet()) {
        if (m.getValue() == "") {
            m.setValue(locptr);
            locptr++;
            mind_the_LC = 1;
        }
    }
}


if(s.equals("EQU")){
    symtab.put("equ", String.valueOf(locptr));
}


if (sCurrentLine.split(" |\\,").length > 2) {     //if there are 3 words
    s = sCurrentLine.split(" |\\,")[2];            //consider the 3rd word

    //this is our first operand.
    //it must be either a Register/Declaration/Symbol
    if (s.equals("AREG")) {
        bw.write("1\t");
        isOpcode = 1;
    } else if (s.equals("BREG")) {
```

```
                    bw.write("2\t");
                    isOpcode = 1;
                } else if (s.equals("CREG")) {
                    bw.write("3\t");
                    isOpcode = 1;
                } else if (s.equals("DREG")) {
                    bw.write("4\t");
                    isOpcode = 1;
                } else if (type == "dl") {
                    bw.write("C\t" + s + "\t");
                } else {
                    symtab.put(s, "");          //forward referenced symbol
                }
            }

            if (sCurrentLine.split(" |\\,").length > 3) {     //if there are 4 words

                s = sCurrentLine.split(" |\\,")[3];          //consider 4th word.
                //this is our 2nd operand
                //it is either a literal, or a symbol
                if (s.contains("=")) {
                    littab.put(s, "");
                    bw.write("L\t" + litptr + "\t");
                    isOpcode = 1;
                    litptr++;
                } else {
                    symtab.put(s, "");
                    //
                    bw.write("S\t" + symptr + "\t");
                    symptr++;

                }
            }

            bw.write("\n");       //done with a line.

            if (mind_the_LC == 0)
                locptr++;
        }

        System.out.println("Imperative Statements-------");
        for (Object objectName : is.keySet()) {
            System.out.println(objectName+"\t"+is.get(objectName));
        }

        System.out.println("Assembler Directive-------");
        for (Object objectName : ad.keySet()) {
            System.out.println(objectName+"\t"+is.get(objectName));
        }

        System.out.println("Declarative Statements-------");
        for (Object objectName : dl.keySet()) {
            System.out.println(objectName + "\t" + dl.get(objectName));
        }

        System.out.print("\n---------Symbol Table------ \n");
        String f1 = "E:\\pass1_assembler\\OUTPUT\\SYMTAB.txt";
        FileWriter fw1 = new FileWriter(f1);
        BufferedWriter bw1 = new BufferedWriter(fw1);
        for (Map.Entry m : symtab.entrySet()) {
            bw1.write(m.getKey() + "\t" + m.getValue()+"\n");
            System.out.println(m.getKey() + " " + m.getValue());
        }

        System.out.print("\n---------Literal Table------ \n");
        String f2 = "E:\\pass1_assembler\\OUTPUT\\LITTAB.txt";
        FileWriter fw2 = new FileWriter(f2);
        BufferedWriter bw2 = new BufferedWriter(fw2);
        for (Map.Entry m : littab.entrySet()) {
            bw2.write(m.getKey() + "\t" + m.getValue()+"\n");
            System.out.println(m.getKey() + " " + m.getValue());
        }

        System.out.print("\n---------Pool Table------\n");
        String f3 = "E:\\pass1_assembler\\OUTPUT\\POOLTAB.txt";
        FileWriter fw3 = new FileWriter(f3);
        BufferedWriter bw3 = new BufferedWriter(fw3);
        for (Integer item : pooltab) {
            bw3.write(item+"\n");
            System.out.println(item);
        }

        bw.close();
        bw1.close();
```

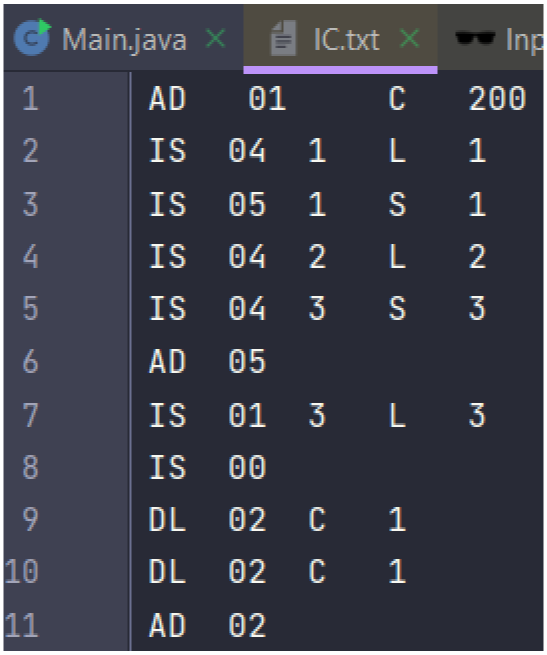
```
            bw2.close();
            bw3.close();

        } catch (IOException e) {
            e.printStackTrace();
        }

    }

}
```

Input file :-



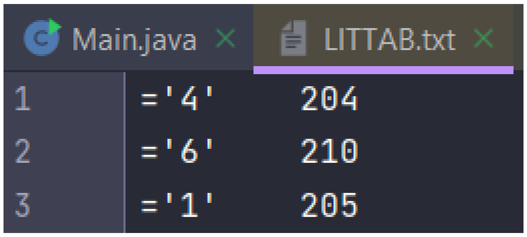
```
 START 200
 MOVER AREG,='4'
 MOVEM AREG,A
 MOVER BREG,='1'
LOOP MOVER CREG,B
 LTORG
 ADD CREG,='6'
 STOP
A DS 1
B DS 1
 END
```

Output File:-



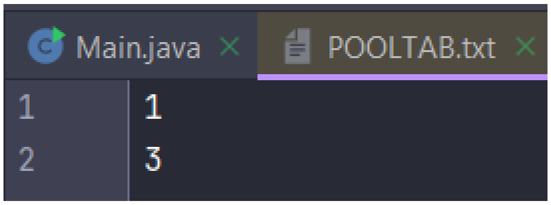
```
AD   01        C    200
IS   04   1    L    1
IS   05   1    S    1
IS   04   2    L    2
IS   04   3    S    3
AD   05
IS   01   3    L    3
IS   00
DL   02   C    1
DL   02   C    1
AD   02
```

1) Intermediate code IC.txt



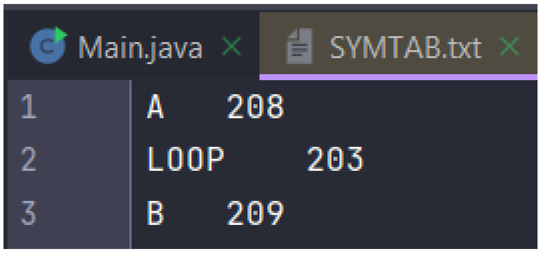
```
='4'    204
='6'    210
='1'    205
```

2) Literal Table LITTABLE.txt



```
1
3
```

3) Pool Table POOLTAB.txt



```
A    208
LOOP     203
B    209
```

4) Symbol Table SYMTAB.txt