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Date:- 24-11-2020

Computer Architecture - CS321/CS322

Project Report: Two pass assembler for an extended SIMPLE instruction set with emulator.

ASSUMPTIONS:

- If a value is in Hexadecimal it would always start with '0x'.
- If a value is in Octal it would always start with '0'.
- If any operand is missing or invalid the error is 'improper operand'.
- The Pass1 of the assembler outputs no code and does not fail on undefined labels.
- The size of DATA and SET instructions is assumed to be 32 bits.
- The labels can have '_' anywhere in their names.

SUBMISSION:

- The name of the assembler source file is **asm.cpp**
- The name of the emulator source file is **emu.cpp**
- The assembler file and emulator with various .asm, .lst, .obj, .o and .txt files are attached in the zip file.
- The **claims.txt** is also attached in the zip file.
- Files used for testing:
 - test1.asm --given
 - test2.asm --given
 - test3.asm --given
 - test4.asm --given
 - MyBubbleSort.asm --given
 - sampletest1.asm --additional working test file created by me.
 - sampletest2.asm --additional test file containing errors created by me.

EXPLANATION OF C++ Code:

- The data structures like maps, vectors and arrays are declared to store values such as instructions, operands, opcodes, etc.
- Declared functions like removeUnecesarySpaces, removeComment, opcode_to_hex_string, etc. for carrying out various functions.
- In main first the init() function is called to initialize instruct_table and error_table. Then the extension of the file is checked. If the extension is not '.asm' then error is printed on the screen. Then Pass1() and Pass2() are called.
- The SET instruction is implemented.
- In Pass1() the program is read line by line and errors like 'extra on end of line', 'improper operand', etc are taken into account. The instructions without labels and offsets are taken care of. The program counter is also dealt with in this pass.
- In Pass2() the errors regarding labels are taken into account. The '.lst' , '.log' and '.o' files are created.
- Finally in Pass2() writeObjFile function is called if there are no errors. We are opening a .o file as "wb" which stands for writebinary. The hex machine code obtained is converted to int and written into the '.o' file.
- It is compiled and used using the following commands:
 - **g++ asm.cpp -o asm**
 - **./asm filename.asm**

Implementing SET instruction:

- Check if there is a label name before a SET instruction.
- Check the value after SET and update the machine code accordingly.

Compiling and Using the assembler:

Use the following commands:

- **g++ asm.cpp -o asm**
- **./asm filename.asm**

Compiling and Using the emulator:

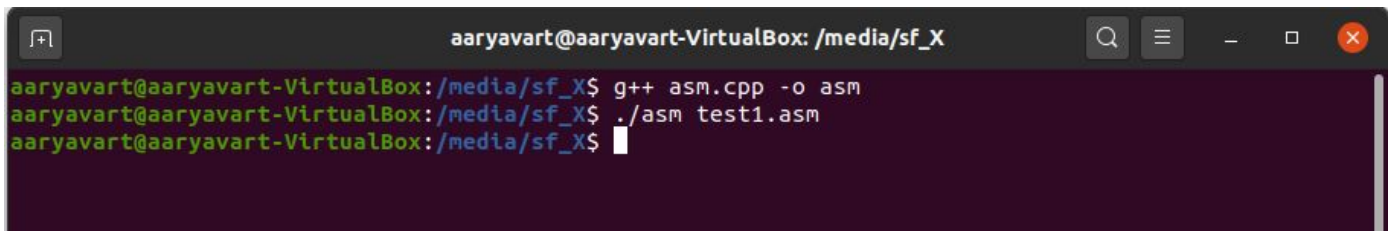
Use the following commands:

- **g++ emu.cpp -o emu**
- **./emu filename.o**

SCREENSHOTS:

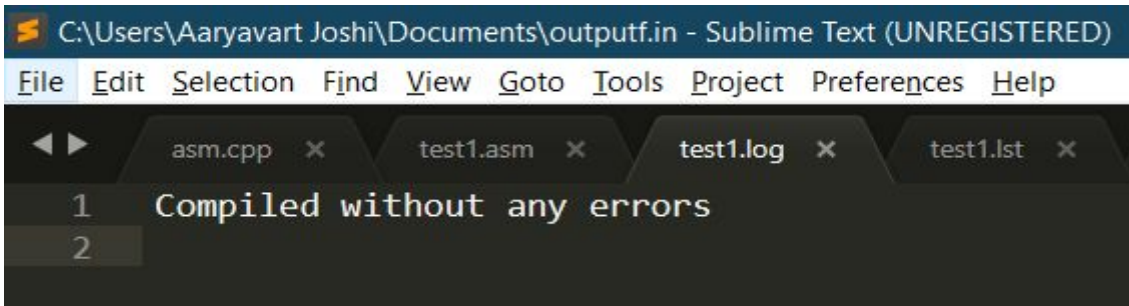
(Evidence that the assembler works for all the test files)

1. **Running test1.asm** -- compiles without any errors



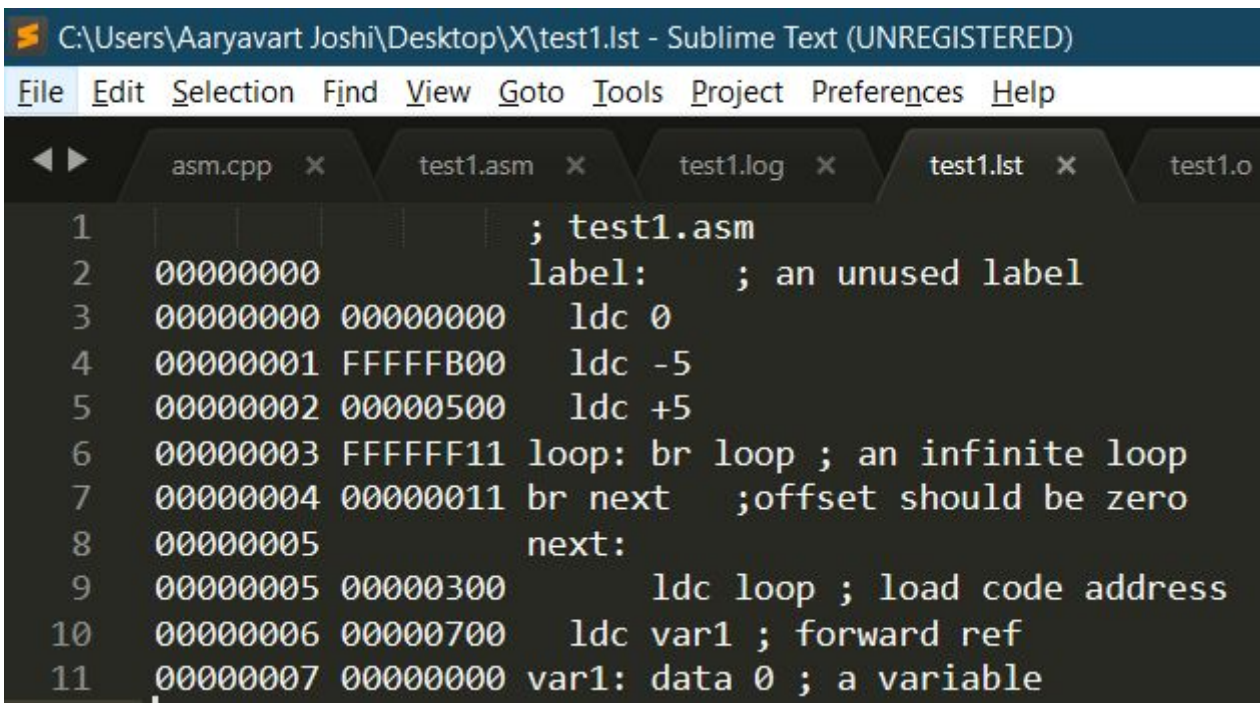
```
aaryavart@aaryavart-VirtualBox: /media/sf_X
aaryavart@aaryavart-VirtualBox:/media/sf_X$ g++ asm.cpp -o asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$ ./asm test1.asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$
```

test1.log



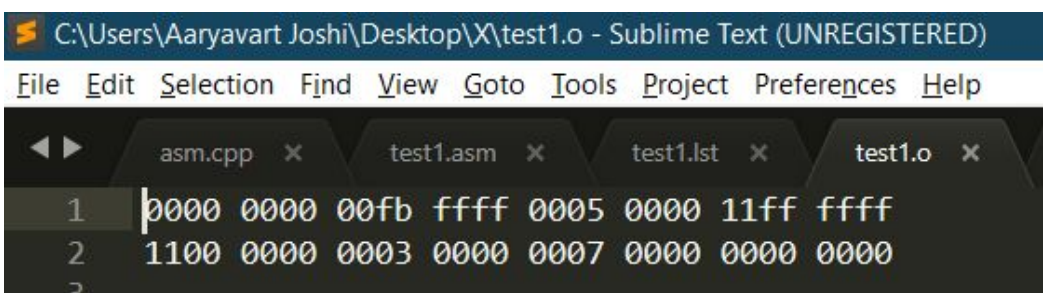
```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test1.asm x test1.log x test1.lst x
1 Compiled without any errors
2
```

test1.lst



```
C:\Users\Aaryavart Joshi\Desktop\X\test1.lst - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test1.asm x test1.log x test1.lst x test1.o
1 ; test1.asm
2 00000000 label: ; an unused label
3 00000000 00000000 ldc 0
4 00000001 FFFFFB00 ldc -5
5 00000002 00000500 ldc +5
6 00000003 FFFFFFF11 loop: br loop ; an infinite loop
7 00000004 00000011 br next ;offset should be zero
8 00000005 next:
9 00000005 00000300 ldc loop ; load code address
10 00000006 00000700 ldc var1 ; forward ref
11 00000007 00000000 var1: data 0 ; a variable
```

test1.o



```
C:\Users\Aaryavart Joshi\Desktop\X\test1.o - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test1.asm x test1.lst x test1.o x
1 0000 0000 00fb ffff 0005 0000 11ff ffff
2 1100 0000 0003 0000 0007 0000 0000 0000
3
```

2. Running test2.asm -- compiles giving errors in the log file.

```
aaryavart@aaryavart-VirtualBox: /media/sf_X
aaryavart@aaryavart-VirtualBox:/media/sf_X$ g++ asm.cpp -o asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$ ./asm test2.asm
ERROR: duplicate label definition on line number 4
ERROR: improper operand on line number 7
ERROR: improper operand on line number 8
ERROR: extra on end of line on line number 9
ERROR: bogus label name on line number 10
ERROR: bogus mnemonic on line number 11
ERROR: bogus mnemonic on line number 12
ERROR: bogus label name on line number 5
ERROR: bogus label name on line number 6
aaryavart@aaryavart-VirtualBox:/media/sf_X$
```

test2.log

```
C:\Users\Aaryavart Joshi\Desktop\X\test2.log - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test2.asm x test2.log x test2.lst x
1 ERROR: duplicate label definition on line number 4
2 ERROR: improper operand on line number 7
3 ERROR: improper operand on line number 8
4 ERROR: extra on end of line on line number 9
5 ERROR: bogus label name on line number 10
6 ERROR: bogus mnemonic on line number 11
7 ERROR: bogus mnemonic on line number 12
8 ERROR: bogus label name on line number 5
9 ERROR: bogus label name on line number 6
10
```

test2.lst

```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test2.asm x test2.log x test2.lst x
1 ; test2.asm
2 ; Test error handling
3 00000000 label:
4
```

****No '.o' file is created for test2.asm because there were errors in the code.**

3. **Running test3.asm** -- Compiles without any errors.

```
aaryavart@aaryavart-VirtualBox: /media/sf_X
aaryavart@aaryavart-VirtualBox:/media/sf_X$ g++ asm.cpp -o asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$ ./asm test3.asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$
```

--SET instruction is demonstrated in this asm program.

test3.log

```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGIS
File Edit Selection Find View Goto Tools Project Preferences H
asm.cpp x test3.asm x test3.log x test3.ls
1 Compiled without any errors
2
```

test3.lst

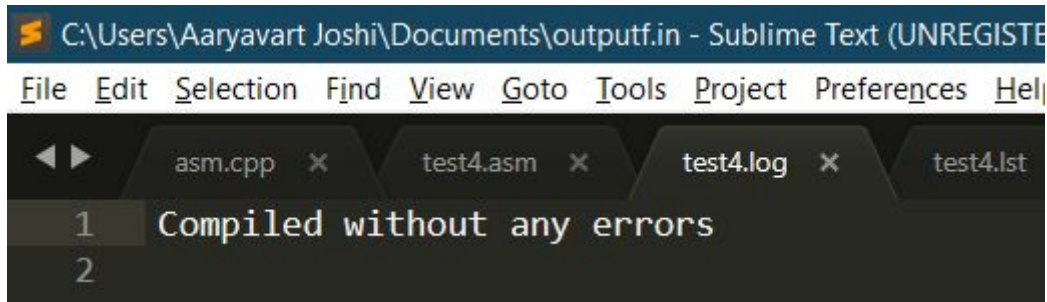
```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test3.asm x test3.log x test3.lst x
1 ; test3.asm
2 ; Test SET
3 00000000 0000004B val: SET 75
4 00000001 00004B00 ldc val
5 00000002 00004201 adc val2
6 00000003 00000042 val2: SET 66
```

test3.o

```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x test3.asm x test3.log x test3.lst x test3.o x
1 4b00 0000 004b 0000 0142 0000 4200 0000
2
```

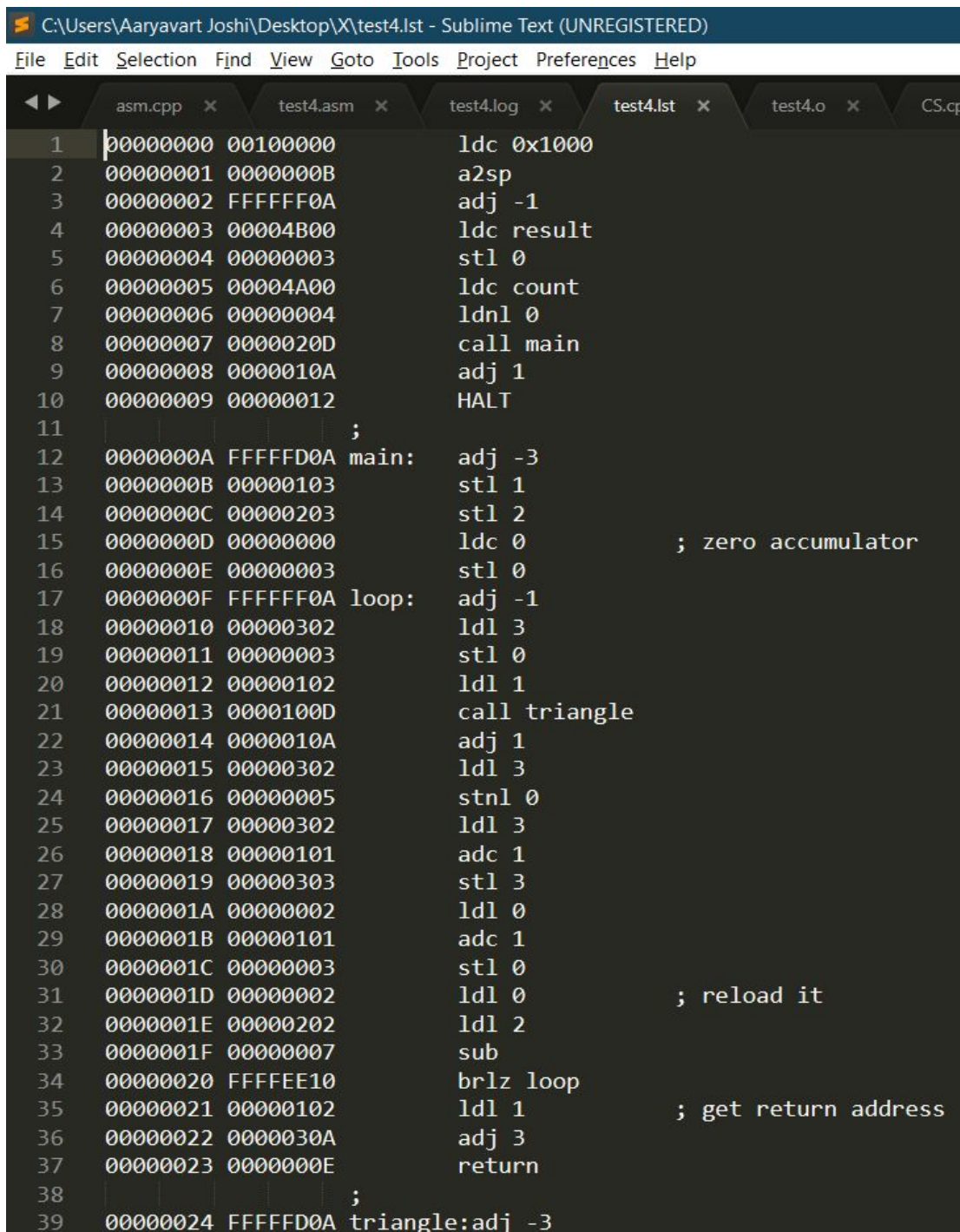
4. **Running test4.asm** -- Compiles without any errors

test4.log

A screenshot of the Sublime Text editor window. The title bar reads "C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)". The menu bar includes File, Edit, Selection, Find, View, Goto, Tools, Project, Preferences, and Help. The tab bar shows four tabs: asm.cpp, test4.asm, test4.log (active), and test4.lst. The content of the active tab is:

```
1 Compiled without any errors
2
```

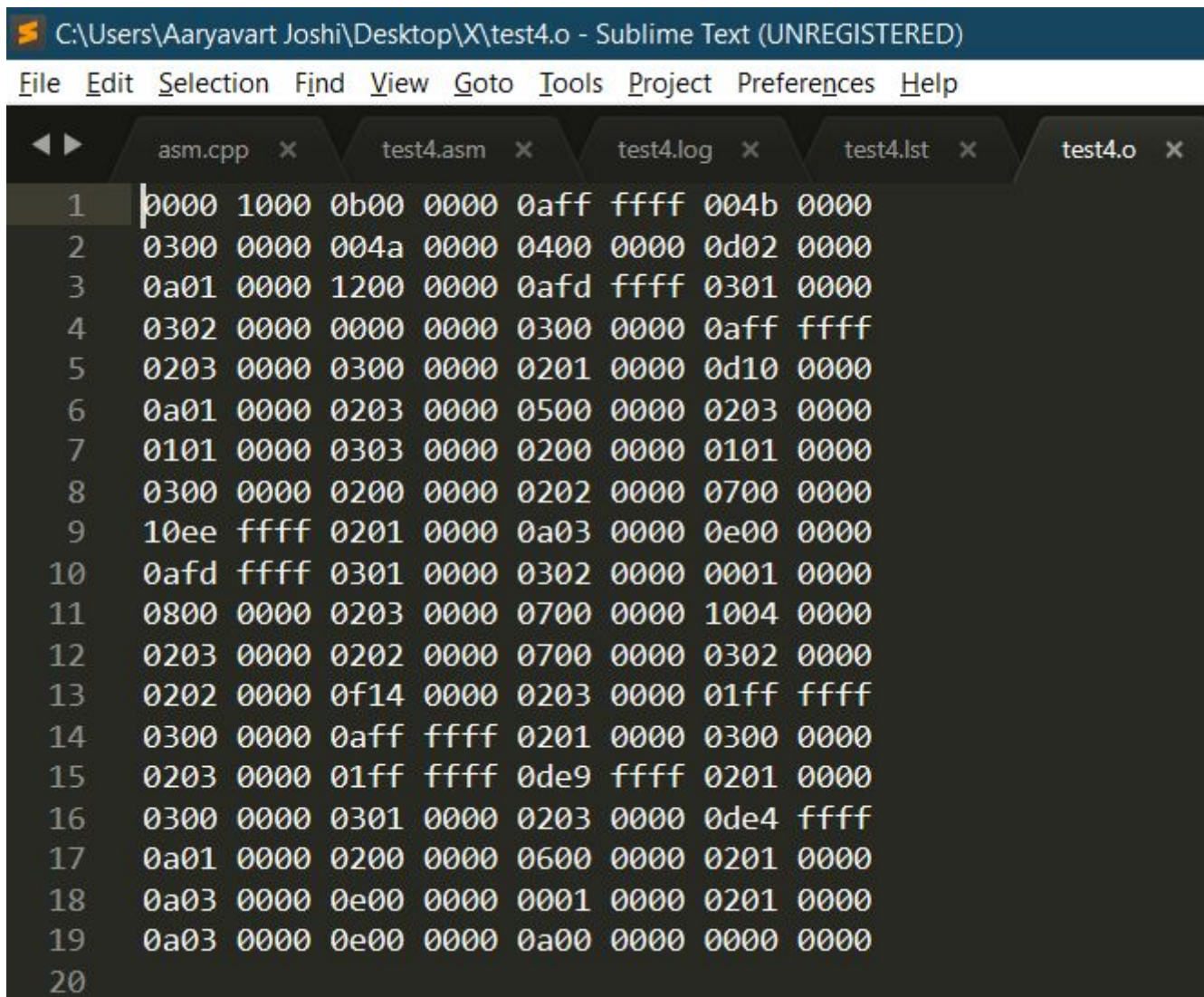
test4.lst

A screenshot of the Sublime Text editor window. The title bar reads "C:\Users\Aaryavart Joshi\Desktop\X\test4.lst - Sublime Text (UNREGISTERED)". The menu bar includes File, Edit, Selection, Find, View, Goto, Tools, Project, Preferences, and Help. The tab bar shows seven tabs: asm.cpp, test4.asm, test4.log, test4.lst (active), test4.o, and CS.cp. The content of the active tab is:

```
1 00000000 00100000      ldc 0x1000
2 00000001 0000000B      a2sp
3 00000002 FFFFFFF0A     adj -1
4 00000003 00004B00      ldc result
5 00000004 00000003      stl 0
6 00000005 00004A00      ldc count
7 00000006 00000004      ldnl 0
8 00000007 0000020D      call main
9 00000008 0000010A      adj 1
10 00000009 00000012      HALT
11      ;
12 0000000A FFFFFD0A main: adj -3
13 0000000B 00000103      stl 1
14 0000000C 00000203      stl 2
15 0000000D 00000000      ldc 0          ; zero accumulator
16 0000000E 00000003      stl 0
17 0000000F FFFFFFF0A loop: adj -1
18 00000010 00000302      ldl 3
19 00000011 00000003      stl 0
20 00000012 00000102      ldl 1
21 00000013 0000100D      call triangle
22 00000014 0000010A      adj 1
23 00000015 00000302      ldl 3
24 00000016 00000005      stnl 0
25 00000017 00000302      ldl 3
26 00000018 00000101      adc 1
27 00000019 00000303      stl 3
28 0000001A 00000002      ldl 0
29 0000001B 00000101      adc 1
30 0000001C 00000003      stl 0
31 0000001D 00000002      ldl 0          ; reload it
32 0000001E 00000202      ldl 2
33 0000001F 00000007      sub
34 00000020 FFFFE10      brlz loop
35 00000021 00000102      ldl 1          ; get return address
36 00000022 0000030A      adj 3
37 00000023 0000000E      return
38      ;
39 00000024 FFFFFD0A triangle:adj -3
```

.....CONTINUED IN test4.lst attached in ZIP File.

test4.o

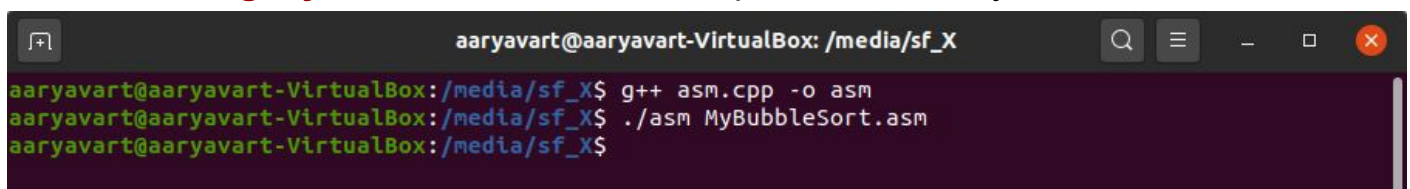


```
C:\Users\Aaryavart Joshi\Desktop\X\test4.o - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help

asm.cpp x test4.asm x test4.log x test4.lst x test4.o x

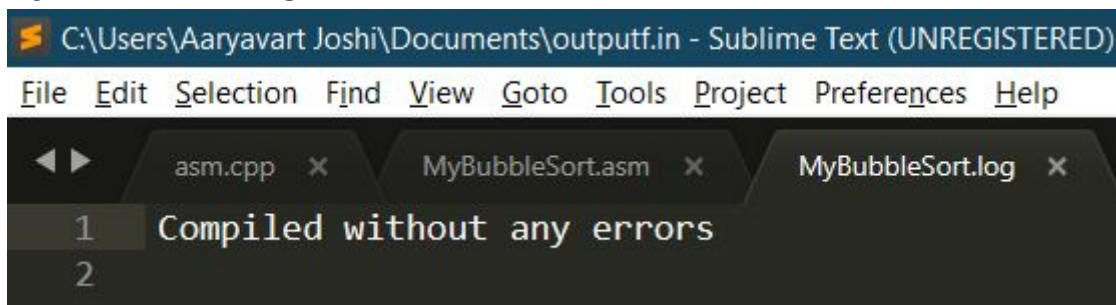
1 0000 1000 0b00 0000 0aff ffff 004b 0000
2 0300 0000 004a 0000 0400 0000 0d02 0000
3 0a01 0000 1200 0000 0afd ffff 0301 0000
4 0302 0000 0000 0000 0300 0000 0aff ffff
5 0203 0000 0300 0000 0201 0000 0d10 0000
6 0a01 0000 0203 0000 0500 0000 0203 0000
7 0101 0000 0303 0000 0200 0000 0101 0000
8 0300 0000 0200 0000 0202 0000 0700 0000
9 10ee ffff 0201 0000 0a03 0000 0e00 0000
10 0afd ffff 0301 0000 0302 0000 0001 0000
11 0800 0000 0203 0000 0700 0000 1004 0000
12 0203 0000 0202 0000 0700 0000 0302 0000
13 0202 0000 0f14 0000 0203 0000 01ff ffff
14 0300 0000 0aff ffff 0201 0000 0300 0000
15 0203 0000 01ff ffff 0de9 ffff 0201 0000
16 0300 0000 0301 0000 0203 0000 0de4 ffff
17 0a01 0000 0200 0000 0600 0000 0201 0000
18 0a03 0000 0e00 0000 0001 0000 0201 0000
19 0a03 0000 0e00 0000 0a00 0000 0000 0000
20
```

5. Running MyBubbleSort.asm -- Compiles without any errors



```
aaryavart@aaryavart-VirtualBox: /media/sf_X
aaryavart@aaryavart-VirtualBox:/media/sf_X$ g++ asm.cpp -o asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$ ./asm MyBubbleSort.asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$
```

MyBubbleSort.log



```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help

asm.cpp x MyBubbleSort.asm x MyBubbleSort.log x

1 Compiled without any errors
2
```

MyBubbleSort.lst

```
C:\Users\Aaryavart Joshi\Desktop\X\MyBubbleSort.lst - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x MyBubbleSort.asm x MyBubbleSort.log x MyBubbleSort.lst x
1 | ; outline of bubble sort program
2 00000000 00100000 ldc 0x1000
3 00000001 0000000B a2sp
4 00000002 FFFFFFF0A adj -1
5 00000003 00000A00 ldc 10
6 00000004 00000003 stl 0
7 00000005 00004100 ldc array
8 00000006 0000010D call sort
9 00000007 00000012 HALT
10 ;
11 ; Areg= return address
12 ; Prog. address of elements
```

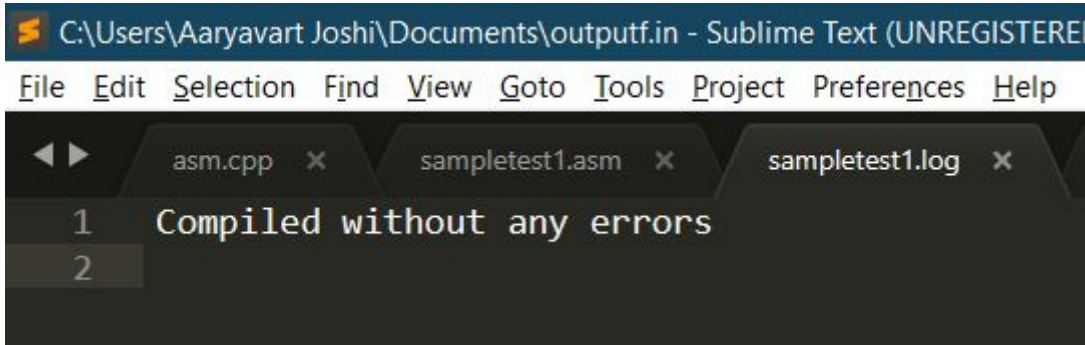
.....CONTINUED IN MyBubbleSort.lst attached in ZIP File.

MyBubbleSort.o

```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x MyBubbleSort.asm x MyBubbleSort.log x MyBubbleSort.lst x MyBubbleSort.o x
1 0000 1000 0b00 0000 0aff ffff 000a 0000
2 0300 0000 0041 0000 0d01 0000 1200 0000
3 0aff ffff 0300 0000 0302 0000 0afd ffff
4 0000 0000 0300 0000 0001 0000 0301 0000
5 0000 0000 0302 0000 0204 0000 0202 0000
6 0700 0000 0001 0000 0700 0000 0f26 0000
7 0001 0000 0301 0000 0204 0000 0202 0000
8 0700 0000 0201 0000 0700 0000 0f16 0000
9 0205 0000 0400 0000 0000 0000 0401 0000
10 0700 0000 1001 0000 110a 0000 0205 0000
11 0400 0000 0300 0000 0205 0000 0401 0000
12 0205 0000 0500 0000 0200 0000 0205 0000
13 0501 0000 0001 0000 0201 0000 0600 0000
14 0301 0000 11e4 ffff 0001 0000 0202 0000
15 0600 0000 0302 0000 0001 0000 0205 0000
16 0600 0000 11d4 ffff 0203 0000 0a05 0000
17 0e00 0000 efbe adde d5be ed5e beba edc0
18 d500 af5e 5a15 5cab edad 5cca cefa edfe
19 0df0 c0c0 eda5 cede d5be fa50
```


6. Running sampletest1.asm -- Compiles without any errors

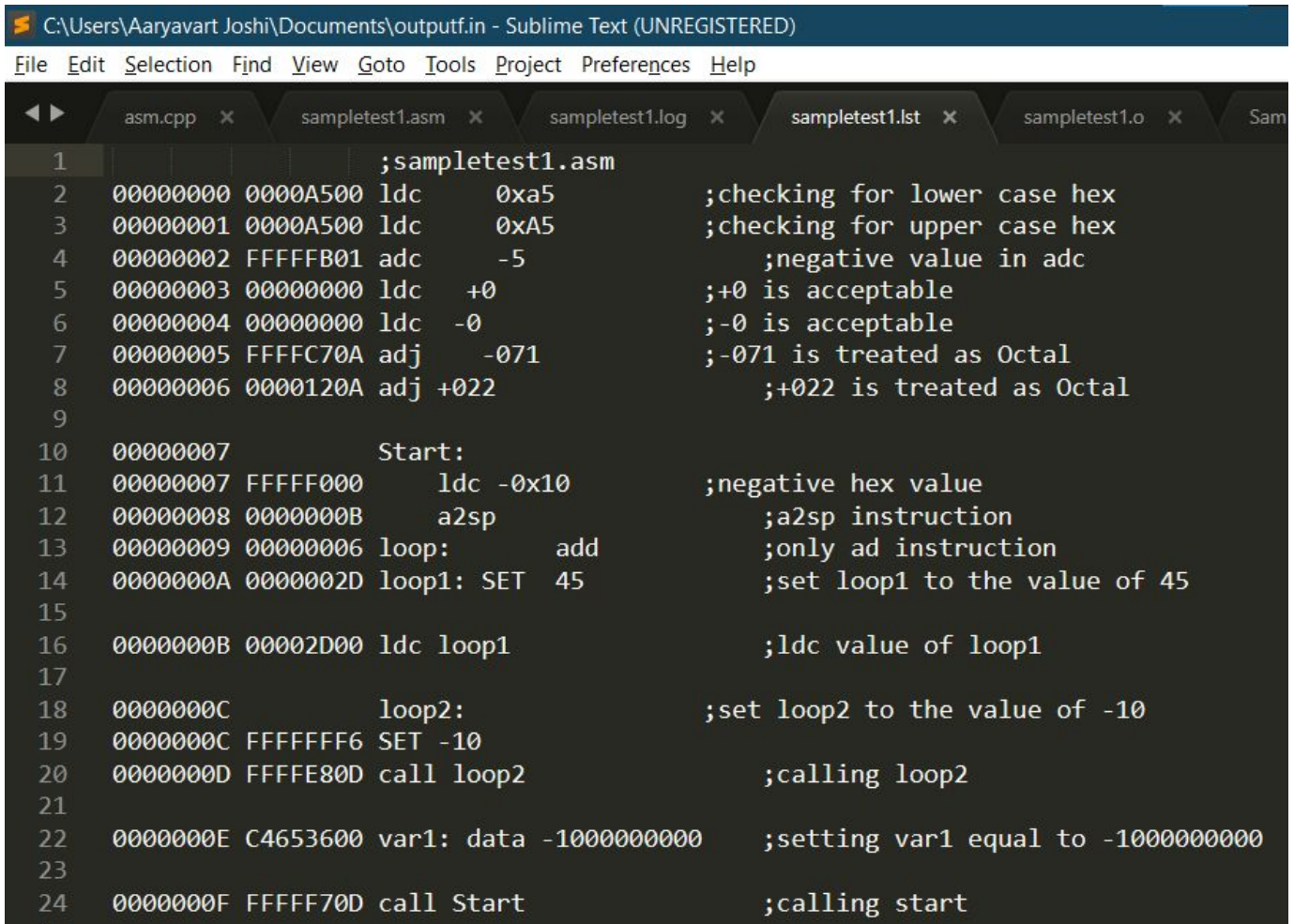
sampletest1.log



A screenshot of the Sublime Text editor window titled "C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)". The menu bar includes File, Edit, Selection, Find, View, Goto, Tools, Project, Preferences, and Help. The tab bar shows three open files: asm.cpp, sampletest1.asm, and sampletest1.log. The sampletest1.log file is active and displays the following content:

```
1 Compiled without any errors
2
```

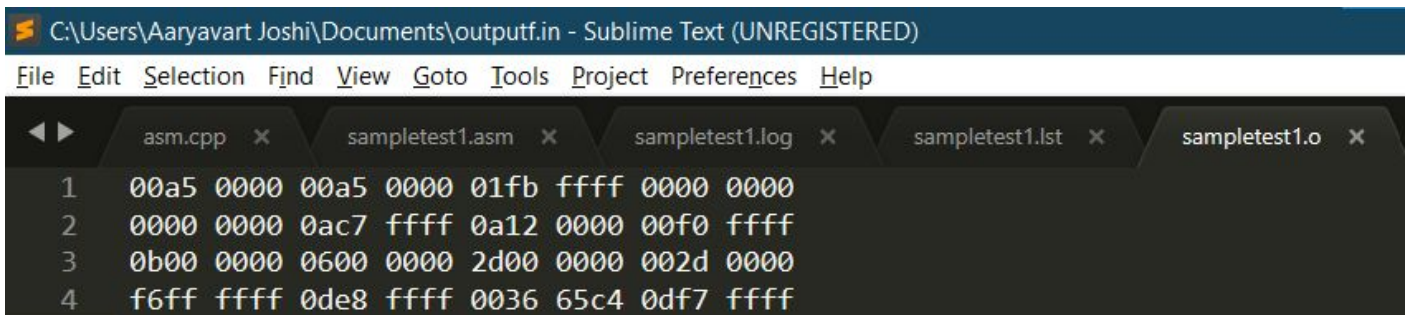
sampletest1.lst



A screenshot of the Sublime Text editor window titled "C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)". The menu bar includes File, Edit, Selection, Find, View, Goto, Tools, Project, Preferences, and Help. The tab bar shows five open files: asm.cpp, sampletest1.asm, sampletest1.log, sampletest1.lst, and sampletest1.o. The sampletest1.lst file is active and displays the following assembly listing:

```
1 ;sampletest1.asm
2 00000000 0000A500 ldc 0xa5 ;checking for lower case hex
3 00000001 0000A500 ldc 0xA5 ;checking for upper case hex
4 00000002 FFFFFB01 adc -5 ;negative value in adc
5 00000003 00000000 ldc +0 ;+0 is acceptable
6 00000004 00000000 ldc -0 ;-0 is acceptable
7 00000005 FFFFC70A adj -071 ;-071 is treated as Octal
8 00000006 0000120A adj +022 ;+022 is treated as Octal
9
10 00000007 Start:
11 00000007 FFFFF000 ldc -0x10 ;negative hex value
12 00000008 0000000B a2sp ;a2sp instruction
13 00000009 00000006 loop: add ;only ad instruction
14 0000000A 0000002D loop1: SET 45 ;set loop1 to the value of 45
15
16 0000000B 00002D00 ldc loop1 ;ldc value of loop1
17
18 0000000C loop2: ;set loop2 to the value of -10
19 0000000C FFFFFFFF6 SET -10
20 0000000D FFFFE80D call loop2 ;calling loop2
21
22 0000000E C4653600 var1: data -1000000000 ;setting var1 equal to -1000000000
23
24 0000000F FFFFF70D call Start ;calling start
25
```

sampletest1.o



A screenshot of the Sublime Text editor window titled "C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)". The menu bar includes File, Edit, Selection, Find, View, Goto, Tools, Project, Preferences, and Help. The tab bar shows five open files: asm.cpp, sampletest1.asm, sampletest1.log, sampletest1.lst, and sampletest1.o. The sampletest1.o file is active and displays the following object code:

```
1 00a5 0000 00a5 0000 01fb ffff 0000 0000
2 0000 0000 0ac7 ffff 0a12 0000 00f0 ffff
3 0b00 0000 0600 0000 2d00 0000 002d 0000
4 f6ff ffff 0de8 ffff 0036 65c4 0df7 ffff
```

7. Running sampletest2.asm -- Compiles giving errors in the log file

```
aaryavart@aaryavart-VirtualBox: /media/sf_X
aaryavart@aaryavart-VirtualBox:/media/sf_X$ g++ asm.cpp -o asm
aaryavart@aaryavart-VirtualBox:/media/sf_X$ ./asm sampletest2.asm
error messages:
ERROR: extra on end of line on line number 3
ERROR: extra on end of line on line number 4
ERROR: bogus mnemonic on line number 5
ERROR: extra on end of line on line number 6
ERROR: improper operand on line number 10
ERROR: bogus mnemonic on line number 11
ERROR: bogus mnemonic on line number 12
ERROR: bogus label name on line number 8
ERROR: bogus label name on line number 9
ERROR: bogus label name on line number 2
ERROR: bogus label name on line number 7
aaryavart@aaryavart-VirtualBox:/media/sf_X$
```

sampletest2.log

```
C:\Users\Aaryavart Joshi\Documents\outputf.in - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x sampletest2.asm x sampletest2.log x samp
1 ERROR: extra on end of line on line number 3
2 ERROR: extra on end of line on line number 4
3 ERROR: bogus mnemonic on line number 5
4 ERROR: extra on end of line on line number 6
5 ERROR: improper operand on line number 10
6 ERROR: bogus mnemonic on line number 11
7 ERROR: bogus mnemonic on line number 12
8 ERROR: bogus label name on line number 8
9 ERROR: bogus label name on line number 9
10 ERROR: bogus label name on line number 2
11 ERROR: bogus label name on line number 7
12
```

sampletest2.lst

```
C:\Users\Aaryavart Joshi\Desktop\X\sampletest2.lst - Sublime Text (UNREGISTERED)
File Edit Selection Find View Goto Tools Project Preferences Help
asm.cpp x sampletest2.asm x sampletest2.log x sampletest2.lst x
1 ;sampletest2.asm
```

****No '.o' file is created for sampletest2.asm because there were errors in the code.**