

# Homework 05

1. An LC-3 assembly language program contains the instruction:

**ASCII LD R1, ASCII**

The label ASCII corresponds to the address x4F08. If this instruction is executed during the running of the program, what will be contained in R1 immediately after the instruction is executed?

2. (Adapted from 7.10) The following program fragment has an error in it. Identify the error and explain how to fix it.

	ADD R3, R3, #30
	ST R3, A
	HALT
A	.BLKW 1

Will this error be detected when this code is assembled or when this code is run on the LC-3?

3. (Adapted from 7.16) Assume a sequence of nonnegative integers is stored in consecutive memory locations, one integer per memory location, starting at location x4000. Each integer has a value between 0 and 30,000 (decimal). The sequence terminates with the value -1 (i.e., xFFFF).
- a. Create the symbol table entries generated by the assembler when translating the following routine into machine code:

	.ORIG x3000
	AND R4, R4, #0
	AND R3, R3, #0
	LD R0, NUMBERS
LOOP	LDR R1, R0, #0
	NOT R2, R1
	BRz DONE
	AND R2, R1, #1
	BRz L1
	ADD R4, R4, #1
	BRnzp NEXT
L1	ADD R3, R3, #1
NEXT	ADD R0, R0, #1
	BRnzp LOOP
DONE	TRAP x25
NUMBERS	.FILL x4000
	.END

b. What does the above program do?

4. (Adapted from 7.18) The following LC-3 program compares two character strings of the same length. The source strings are in the .STRINGZ form. The first string starts at memory location x4000, and the second string starts at memory location x4100. If the strings are the same, the program terminates with the value 1 in R5; otherwise the program terminates with the value 0 in R5. Insert one instruction each at (a), (b), and (c) that will complete the program. Note: The memory location immediately following each string contains x0000.

	.ORIG x3000	
	LD R1, FIRST	
	LD R2, SECOND	
	AND R0, R0, #0	
LOOP	_____	(a)
	LDR R4, R2, #0	
	BRz NEXT	
	ADD R1, R1, #1	
	ADD R2, R2, #1	
	_____	(b)
	_____	(c)
	ADD R3, R3, R4	
	BRz LOOP	
	AND R5, R5, #0	
	BRnzp DONE	
NEXT	AND R5, R5, #0	
	ADD R5, R5, #1	
DONE	TRAP x25	
FIRST	.FILL x4000	
SECOND	.FILL x4100	
	.END	

5. The following program does not do anything useful. However, being an electronic idiot, the LC-3 will still execute it.

	.ORIG x3000
	LD R0, Addr1
	LEA R1, Addr1
	LDI R2, Addr1
	LDR R3, R0, #-6
	LDR R4, R1, #0
	ADD R1, R1, #3
	ST R2, #5
	STR R1, R0, #3
	STI R4, Addr4

	HALT
Addr1	.FILL x300B
Addr2	.FILL x000A
Addr3	.BLKW 1
Addr4	.FILL x300D
Addr5	.FILL x300C
	.END

Without using the simulator, answer the following questions:

- a. What will the values of registers R0 through R4 be after the LC-3 finishes executing the ADD instruction?
  - b. What will the values of memory locations Addr1 through Addr5 be after the LC-3 finishes executing the HALT instruction?
6. The data at memory address x3500 is a bit vector with each bit representing whether a certain power plant in the area is generating electricity (bit = 1) or not (bit = 0). The program counts the number of power plants that generate electricity and stores the result at x3501. However, the program contains a mistake which prevents it from correctly counting the number of electricity generating (operational) power plants. Identify it and explain how to fix it.

	.ORIG x3000
	AND R0, R0, #0
	LD R1, NUMBITS
	LDI R2, VECTOR
	ADD R3, R0, #1
CHECK	AND R4, R2, R3
	BRz NOTOPER
	ADD R0, R0, #1
NOTOPER	ADD R3, R3, R3
	ADD R1, R1, #-1
	BRp CHECK
	STR R0, R2, #1
	TRAP x25
NUMBITS	.FILL #16
VECTOR	.FILL x3500
	.END

7. Assemble the following LC-3 assembly language program.

	.ORIG x3000
	AND R0, R0, #0
	ADD R2, R0, #10
	LD R1, MASK
	LD R3, PTR1
	LOOP LDR R4, R3, #0
	AND R4, R4, R1
	BRz NEXT
	ADD R0, R0, #1
	NEXT ADD R3, R3, #1
	ADD R2, R2, #-1
	BRp LOOP
	STI R0, PTR2
	HALT
MASK	.FILL x8000
PTR1	.FILL x4000
PTR2	.FILL x5000

What does the program do?

8. Which is more efficient, interrupt-driven I/O or polling? Explain.
9. (Adapted from 8.15)

- a. What does the following LC-3 program do?

```

        .ORIG  x3000
        LD   R3, A
        STI  R3, KBSR
AGAIN   LD   R0, B
        TRAP x21
        BRnzp AGAIN
A       .FILL x4000
B       .FILL x0032
KBSR    .FILL xFE00
        .END

```

- b. If someone strikes a key, the program will be interrupted and the keyboard interrupt service routine will be executed as shown below. What does the keyboard interrupt service routine do?

```

        .ORIG x1000
        LDI  R0, KBDR
        TRAP x21
        TRAP x21
        RTI
KBDR    .FILL xFE02
        .END

```

- c. Finally, suppose the program of part (a) started executing, and someone sitting at the keyboard struck a key. What would you see on the screen?

10. (Adapted from 8.16) What does the following LC-3 program do?

```

        .ORIG x3000
        LD   R0, ASCII
        LD   R1, NEG
AGAIN    LDI  R2, DSR
        BRzp AGAIN
        STI  R0, DDR
        ADD  R0, R0, #1
        ADD  R2, R0, R1
        BRnp AGAIN
        HALT
ASCII    .FILL x0041
NEG      .FILL xFFB6
DSR      .FILL xFE04
DDR      .FILL xFE06
        .END

```