

Homework 12: LC-3 Programming

1. LC-3 Programming

For each of the following tasks, systematically decompose the problem to the level of LC-3 instructions, then write LC-3 instructions to implement your solution. Turn in your flow chart and LC-3 instructions in binary. For credit, each instruction must be annotated with a comment in RTL or assembly.

- Problem 6.4 from Patt and Patel. You may only change the contents of R0, R1, and R2.
- Assuming that $0 \leq R4 < 15$, put the 2's complement value 2^{R4} into R3. You may only change the contents of R3 and R4.
- Assuming that $R5 \geq 1$, compute the sum of integers from 1 to R5 and store the result in R2. You may only change the contents of R2 and R5.

2. LC-3 Program Execution

Do problem 6.16 from Patt and Patel. Stop your execution trace when the PC reaches x3003, and do not fill in row x3003 of the table in your solution.

3. Analyzing LC-3 Code

Do problem 7.16 from Patt and Patel.

4. Data or Computation?

Do problem 7.20 from Patt and Patel.

5. Buggy LC-3 Programs

The code below is intended to divide R2 ($R2 \geq 0$) by R4 ($R4 > 0$), leaving the quotient in R3 and the remainder in R1. Unfortunately, the code has a bug. Fix the code **by adding one new instruction**.

**** For credit, do not rewrite the code in any other way. ****

```
.ORIG x3000

; registers R2 and R4 must be initialized first!
START  AND R3,R3,#0
        NOT R4,R4
        ADD R4,R4,#1
LOOP   ADD R0,R2,R4
        BRn BELOW
        ADD R3,R3,#1
        BRnzp LOOP
BELOW  ADD R1,R2,#0
        ; R1 and R3 values are correct here (HALT may change them
        ; in the simulator)
        HALT

.END
```

6. Comparing Algorithms

Two friends are trying to print a line of periods bounded by asterisks to the console. The line is supposed to have $N - 2$ periods, where $N \geq 2$. For example, when $N = 8$, they want to print, “* *” to the console (without quotes).

Each friend has decomposed the task, but they have different results. Look at the two approaches, as represented by the flow charts below.

- Explain which approach is the better of the two and why you believe it to be better.
- Imagine that one must replace each box labeled “print '*'” with a complex algorithm requiring almost 1,000 LC-3 instructions to implement. Repeat your comparison between the two approaches after the replacement described, again explaining why you believe your choice to be the better one.

