

Your Name: \_\_\_\_\_ netid: \_\_\_\_\_  
 Name: \_\_\_\_\_ netid: \_\_\_\_\_  
 Name: \_\_\_\_\_ netid: \_\_\_\_\_  
 Name: \_\_\_\_\_ netid: \_\_\_\_\_

Group #:

## ECE 120 Worksheet 12: Programming in LC-3 machine language

Shown on the right is a flow chart for a constrained version of *multiplication by repeated addition* algorithm (it works only when  $b > 0$ ). In this discussion, you will develop a similar flowchart, but for a different problem: *division by repeated subtraction*. You will then write a program in LC-3 binary language that implements this algorithm.

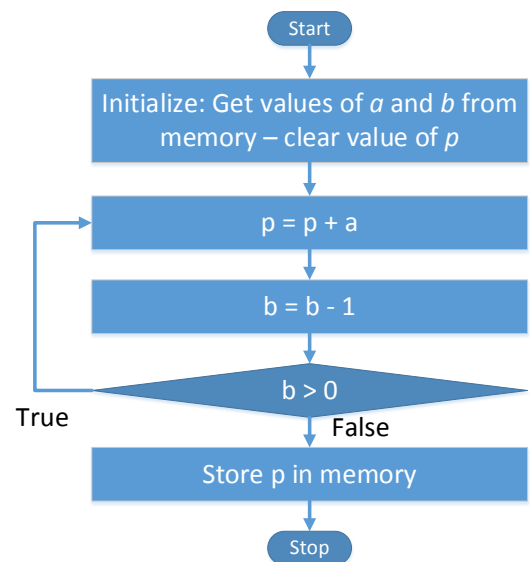
Use the following notation/terminology:

- Q = Quotient
- N = Numerator (dividend)
- D = Denominator (divisor)
- R = Remainder.

For simplicity we will assume that both dividend and divisor are strictly positive numbers. Your algorithm should find both Quotient and Remainder.

Your final program written in the LC-3 binary language should use for input and output the memory locations just after you HALT your program:

- Input
  - Dividend (N)
  - Divisor (D)
- Output
  - Quotient (Q)
  - Remainder (R)



## 1. From problem statement to an algorithm

Describe in clear English the sequential processes (algorithm) you will need to follow to perform *division by repeated subtraction* to compute  $N \div D$ . Your computation should allow finding both quotient,  $Q$ , and remainder,  $R$ .

## 2. Algorithm refinement

Convert your algorithm from Part 1 into a high-level flow chart using sequential, iterative, and conditional constructs. Use English statements and math expressions to describe your steps.

**Hint:** your flowchart at this stage of refinement should be at the level of details of the flowchart shown on page 1 of this discussion booklet.

### 3. Flowchart refinement

Trace through your flow chart, determine how many values you need to use, and assign registers to each of these values. Will you need to use any registers for multiple values?

Redraw your flow chart using RTL statements with your desired registers.

## 4. From flowchart to program

This question will NOT be graded. Try to do as much as you can, since it is good practice for the final exam.

Translate your flowchart into an LC-3 binary program. Values of  $N$ ,  $D$ ,  $Q$ , and  $R$  should be stored in memory in the locations immediately after you HALT. Your program should start at address x3000.

Memory Address	Binary instruction	Assembly instruction	Comments
x3000			
x3001			
x3002			
x3003			
x3004			
x3005			
x3006			
x3007			
x3008			
x3009			
x300A			
x300B			
x300C			
x300D			
x300E			
x300F			
x3010			
x3011			
x3012			
x3013			
x3014			
x3015			
x3016			
x3017			
x3018			
x3019			