

# Code Improvement Exercises

## CS 4610 — Spring 2017

This Review Set asks you to prepare written answers to questions on code improvement. Each of the questions has a short answer. You may discuss this Review Set with other students and work on the problems together.

1. Consider the following fragment of intermediate code:

```
START
  if a = 2 goto L3
L0: b := 2
L1: d := a / 2
   c := a % b
   if c = 0 goto L2
   if b >= d goto L3
   b := b + 1
   goto L1
L2: a := a + 1
   goto L0
L3: END
```

- (a) Divide this code into basic blocks; there should be at least 6. Assume that `START` and `END` are placeholder instructions (i.e. they don't do anything).
- (b) Draw a control-flow graph for this program, using your answer to (a). Place each basic block in a single node.

- (c) Describe concisely what this program does if the value of `a` is the only output.

2. Consider the following section of a flow-graph for a bubble-sort algorithm in three-address code:

$$\begin{array}{ll} t_8 & \leftarrow j - 1 \\ t_9 & \leftarrow 4 * t_8 \\ temp & \leftarrow A[t_9] \\ t_{10} & \leftarrow j + 1 \\ t_{11} & \leftarrow t_{10} - 1 \\ t_{12} & \leftarrow 4 * t_{11} \\ t_{13} & \leftarrow A[t_{12}] \\ t_{14} & \leftarrow j - 1 \\ t_{15} & \leftarrow 4 * t_{14} \\ A[t_{15}] & \leftarrow t_{13} \\ t_{16} & \leftarrow j + 1 \\ t_{17} & \leftarrow t_{16} - 1 \\ t_{18} & \leftarrow 4 * t_{17} \\ A[t_{18}] & \leftarrow temp \end{array}$$

Use the following local optimizations we discussed in class to improve the code (show all steps):

- (a) Algebraic simplification
- (b) Constant folding
- (c) Common subexpression elimination
- (d) Copy propagation
- (e) Dead code elimination