

Spring, 2014

Name: \_\_\_\_\_

(Please *don't* write your id number!)

COP 5021 — Program Analysis  
**Midterm Exam**

This test has 8 questions and pages numbered 1 through 3.

This test is open book and notes, but no electronics.

If you need more space, use the back of a page. Note when you do that on the front.

Before you begin, please take a moment to look over the entire test so that you can budget your time.

Clarity is important; if your answers are sloppy and hard to read, you may lose some points.

**For Grading**

|           |    |    |    |    |   |   |    |    |       |
|-----------|----|----|----|----|---|---|----|----|-------|
| Question: | 1  | 2  | 3  | 4  | 5 | 6 | 7  | 8  | Total |
| Points:   | 10 | 30 | 10 | 10 | 5 | 5 | 10 | 20 | 100   |
| Score:    |    |    |    |    |   |   |    |    |       |

1. (10 points) [Concepts] What is the overall goal of your semester project (i.e., that of your group, if you are in a group)?

2. (30 points) [Concepts] Describe, in English, up to 3 analysis questions that your semester project needs to answer in order to achieve its goal.

3. (10 points) [Concepts] Give an example of what “soundness” means for one of the program analyses that we have studied this semester.

## Assigned a Constant Analysis

The following questions concern checking a WHILE language program to find which variables must have been assigned the value of a numeric (integer) constant, at each program point. This information could (outside of this problem) be used to optimize expression evaluation by replacing variable accesses with loads of that constant.

We say that the a variable  $x$  has been assigned a constant  $n$  at a given program point if  $x$  must have been assigned the value of  $n$  on every path leading to that program point. We call this analysis the “Assigned a Constant” (AC) analysis.

Consider the following example.

```
[i := n]1;
[j := 0]2;
if [i > 0]3 then [m := 3]4 else [m := 4]5;
[j := 9]6;
[k := j]7
```

In this example, at no program point has  $i$  been assigned a constant. The variable  $j$  has been assigned the constant 0 at exit from elementary block 2 and at entry and exit to blocks 3–5 (inclusive) and at entry to block 6, but at exit from block 6 (and also at entry and exit to block 7)  $j$  has been assigned the constant 9. At exit from block 4  $m$  has been assigned the constant 3, and at exit from block 5  $m$  has been assigned the constant 4. However, at entry to block 6,  $m$  has not been assigned a constant, since one cannot tell if it was assigned 3 or 4. Also, the definition of “having been assigned a constant” is not transitive, so at exit from label 7,  $k$  has not been assigned a constant.

4. (10 points) [Concepts] Could the Assigned a Constant analysis be formulated as a type system (as opposed to a dataflow analysis)? Answer “yes” or “no” and briefly justify your answer.

5. (5 points) [Concepts] As a dataflow analysis, would the Assigned a Constant analysis be best thought of as a forward or backward analysis? Answer “forward” or “backward” and briefly justify your answer.
  
6. (5 points) [Concepts] As a dataflow analysis, would the Assigned a Constant analysis be best thought of as a “may” or a “must” analysis? Answer “may” or “must” and briefly justify your answer.
  
7. (10 points) [Concepts] Suppose we decided to formulate the Assigned a Constant analysis as a dataflow analysis. What property space would be best for this analysis? (Clearly define the property space.)
  
8. (20 points) Using the property space in your answer above, write dataflow equations to formalize the Assigned a Constant analysis.