CMSC430 Spring 2011 Midterm 3

Name_____

Instructions

- You have 50 minutes to take this exam.
- This exam has a total of 100 points. An average of 30 seconds per point.
- This is a closed book exam. No notes or other aids are allowed.
- If you have a question, please raise your hand and wait for the instructor.
- Answer essay questions concisely using 1-2 sentences. Longer answers are not necessary and a penalty may be applied.
- In order to be eligible for partial credit, show all of your work and clearly indicate your answers.
- Write neatly. Credit cannot be given for illegible answers.

	Problem	Score	Max Score
1	Compiler optimizations		12
2	Control flow analysis		10
3	CFG ordering, dominators, loops		12
4	Data-flow equations		8
5	Local information		10
6	Live variables		32
7	Dataflow analysis frameworks		16
	Total		100

1. (12 pts) Compiler optimizations

    a. (4 pts) Give an example of how compiler optimizations improve programmer productivity by supporting high-level language abstractions. Name a specific programming language construct.

    b. (4 pts) Explain why compiler optimizations are typically organized as passes over the program.

    c. (4 pts) Describe partial redundancy elimination and how it improves performance.

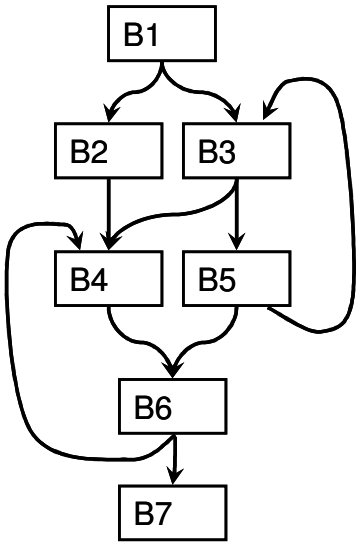
2. (10 pts) Control flow analysis

Consider the following code:

```
<I1>          a := b
<I2>    L1:   b := c
<I3>          if (...) goto L4
<I4>          c := b
<I5>    L2:   d := a
<I6>    L3:   goto L1
<I7>    L4:   b := a
<I8>    L5:   if (...) goto L2
```

Find basic blocks and draw the control flow graph (CFG).

3. (12 pts) CFG ordering, dominators, loops
   Consider the following control flow graph, where B1 is the start of the program.



   a. (6 pts) Give 2 different reverse Postorder numberings of the control flow graph.

   b. (2 pts) List all basic blocks dominated by B3.

   c. (2 pts) List all basic blocks dominated by B4.

   d. (2 pts) List all the loops in the control flow graph. For each loop list all basic blocks in the loop.

4. (8 pts) Data-flow equations

   Consider the control flow graph (CFG) in Problem 3. Assume you are given IN/OUT for all the basic blocks *except* for B4, and GEN/KILL for B4. Show the data-flow equations for IN/OUT for B4 (e.g., IN(B4) = OUT(B1)).

   a. (4 pts) For forward data-flow problems

   b. 4 pts) For backwards data-flow problems

5. (10 pts) Local information

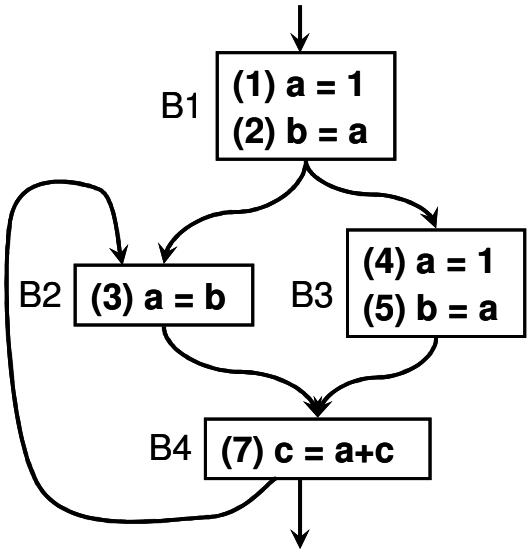
   Consider the following basic block for available expressions:

```
I1:  b = a+c
I2:  d = b*d
I3:  a = b+c
I4:  e = b*a
I5:  a = a+b
```

   a. (5 pts) What is GEN for the basic block?

   b. (5 pts) What is KILL for the basic block?

6. (32 pts) Data flow analysis:
   Consider the following control flow graph for live variables:



   a. (8 pts) Calculate GEN/KILL for each basic block

b. (24 pts) Solve live variables, showing IN/OUT for each pass. Assume everything is initialized to Ø.

7. (16 pts) Data-flow analysis frameworks

   Recall that $\wedge$ is used in data-flow iterative analysis to combine information where paths merge.

   a. (4 pts) How is the $\wedge$ operator used to define the $\leq$ and $<$ operators?

   b. (4 pts) For very busy expressions, pick values for a, b, c for which $a < b$ and $b < c$.

   c. (4 pts) For reaching definitions, pick values for a, b for which neither $a \leq b$ or $b \leq a$ are true.

   d. (4 pts) How can iterative dataflow analysis problems be formulated so that they are guaranteed to eventually stabilize and terminate?