COP5621 Compiler Construction Exam 4 - Spring 2007

Name: _____ (Please print)

Put the answers on these sheets. Use additional sheets when necessary. You can collect 100 points in total for this exam.

1. Which of the following optimizations is considered a *peephole optimization*? (mark **one**)(4 points)

   (a) Common-subexpression elimination

   (b) Code motion

   (c) Branch chaining

   (d) Register assignment

2. Subroutine frames (activation records) manage a procedure's local data. For a typical programming language implementation, who *deallocates* the frame? (mark **one**)(4 points)

   (a) Caller

   (b) Callee

   (c) Caller and callee

   (d) None of the above

3. List three *local optimizations* of your choice and describe what they optimize. (9 points)

4. Consider the following program:

```
program P()
   var p : integer;
   procedure Q(k : integer)
      begin
         R(k, p)
      end
   procedure R(i : integer, j : integer);
      var n : integer
      procedure T(i : integer)
         begin
           ... (* body of T *)
         end;
      procedure S()
         var m : integer
         begin
           T(n)
         end;
      begin
         S()
      end;
begin
   Q(p)
end
```

   (a) Program `P` calls `Q`, `Q` in turn calls `R`, `R` in turn calls `S`, and `S` in turn calls `T`. Draw the resulting stack layout with *activation records*. Show the arguments and local variables in each record and draw the *access links*. (10 points)

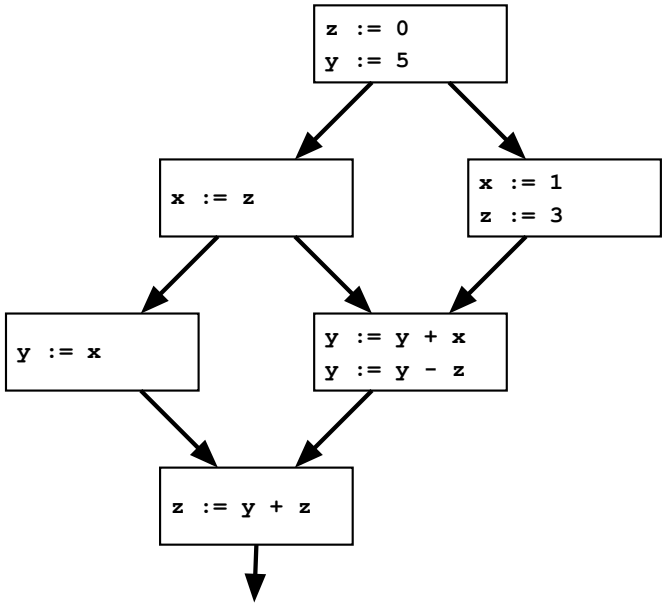
(b) Which variables are visible (in scope) in the body of `T` and how many access links must be traversed to reach the nonlocal data? (6 points)

Var	*visible (Y/N)*	*#links*
`i`		
`j`		
`k`		
`m`		
`n`		
`p`		

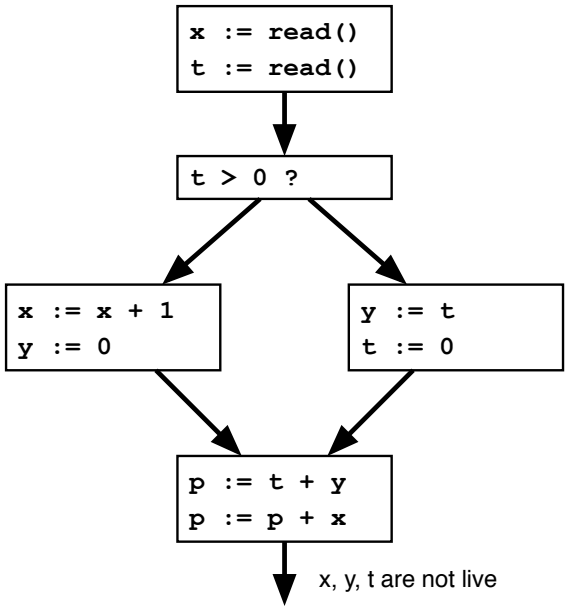
5. Partition the following fragment of three-address code into *basic blocks* and construct the CFG. (9 points)

```
     if n>0 goto L1
     goto L3
L1:  i := 0
     f := 1
L2:  i := i + 1
     f := f * i
     if i<n goto L2
     goto L4
L3:  f := 0
L4:  halt
```

6. Apply *global constant propagation* to the following CFG.(8 points)

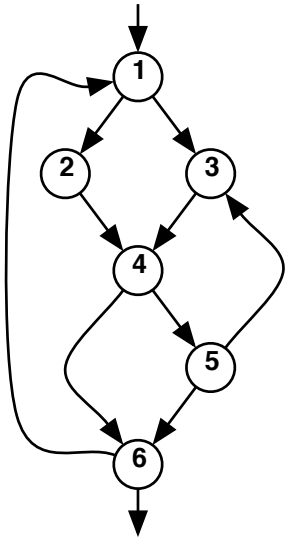


7. Apply *register allocation and assignment* using *graph coloring* to the following CFG:



Hint: show the live ranges of the variables in the CFG, assuming that `x`, `y`, and `t` are no longer live at the exit from the CFG. Draw the *register-interference graph* (*conflict graph*) for the variables and determine the minimum number of colors to color the graph. (12 points)

8. Consider the following CFG:



(a) Draw the *dominator tree* of the CFG. (8 points)

(b) Identify the *natural loops*. (5 points)

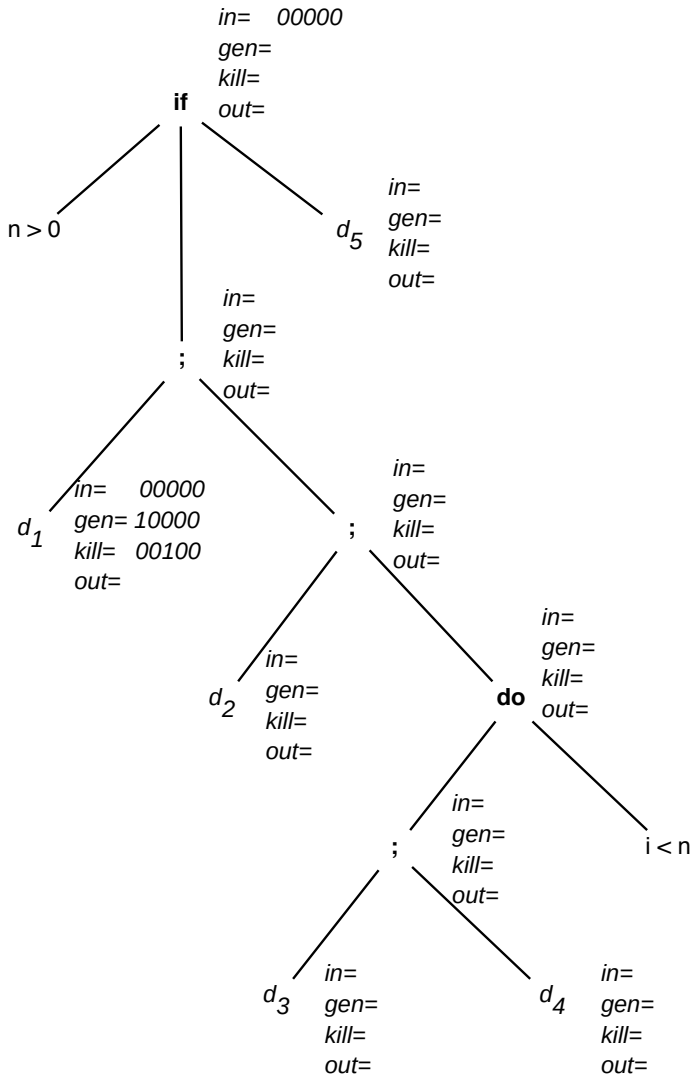
(c) Is the CFG *reducible*? Explain why or why not. (5 points)

9. Give the data-flow equations for reaching definitions (*gen*, *kill*, *in* and *out* sets) as described in the book and illustrated in class for the four programming constructs (assignment, statement composition, if-then-else, and do-while). (10 points)

10. Consider the following program:

```
        if n>0 then
d1 :       i := 0;
d2 :       f := 1;
           do
d3 :          i := i + 1;
d4 :          f := f * i
           while i < n;
        else
d5 :       f := 0;
        end if
```

Annotate the syntax tree of the program with *in*, *gen*, *kill*, and *out* bit-vectors:



Hint: compute the *gen* and *kill* vectors bottom-up first, i.e. start at the leaves. Then compute the *in* and *out* vectors in a top-down, left-to-right traversal. (*in* is inherited, while *out* is synthesized.) (10 points)