Homework 4

Due Date: Thursday, March 16, 2006, 2:00PM

Your Name: _____

Your Email: _____

Question 1 What is the input to target code generation phase?

_____

What are three possible forms of the output?

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Question 2 Describe what I call "Code Generation Algorithm #1".

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Question 3 What is the "register allocation problem"?

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What is the "register assignment problem"?

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Question 4 The IR code imposes an order on the operations. Does "code generation algorithm #1" change this order? _____

Does "code generation algorithm #2" change this order? _____

Does "code generation algorithm #3 (tiling)" change this order? _____

Question 5 A Basic Block is a sequence of consecutive statements, such that

control only enters... (where?)_____

controls only exits... (where?)_____

Question 6 All the basic blocks of a routine are combined into ... what?

_____

Question 7 Given the sequence of IR statements in a routine, we'd like to be able to break it into basic blocks. The approach is to first identify "leaders." Then we define a basic block as a leader and all the statements that follow it, up to (but not including) the next leader. Which statements are leaders?

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Question 8 Given a basic block B, define the "use set", USE (B).

_____

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Question 9 Given a basic block B, define the "def set", DEF (B).

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Question 10 Here is a basic block. What is its USE-set and it DEF-set?

        w := 5 + x
        e := d * b
        a := e − w
        if w < c then goto Label_45

USE (B) =_____

DEF (B) =_____

Question 11 Define what it means for a variable x to be "live" at some point P in a program.

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Question 12 Consider this code sequence:

      a := b + c
      < point P >
      b := d - 5
      d := a * c

Is "a" live at point P? _____

Is "b" live at P? _____

Is "c" live at P? _____

Question 13 "Dead code" can mean two things. What are they?

_____

_____

Question 14 A loop with multiple entries is said to be... what? _____
Structured programming (while, if, repeat-until, but not goto's) results in what kind of

loops? _____

Question 15 In determining next-use information within a basic block, do we work

through the block in forward or reverse order? _____

Question 16 Code generation algorithm #2 uses two data structures. What are they? called?

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Question 17 Describe "code generation algorithm #2" in general terms.

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Question 18 What is "global register allocation"?

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Question 19 What is one problem with putting a variable in a register throughout the entire routine?

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Question 20 Here is some IR code containing a loop.

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        y := a + b
        y := y * 6
        y := y + 5
        x := y
   Label:
        s := s + x
        x := x + 3
        if x < 1000 goto Label
        y := y * x
```

Variable **y** appears 8 times, **x** appears 5 times, and **s** appears 2 times. If we can only choose 1 of these variables to put in a register, which should we choose and why?

_____

_____

Question 21 Assume the following variables are live simultaneously:

     X and Z

     X and U   Y

     Y and Z

     Y and V   X   Z

     Z and U

     Z and V   U   W

     Z and W

     U and V   V

     V and W

(1) Finish drawing the register interference graph shown above.

(2) Assume there are three registers / colors:

     R0 = red

     R1 = blue

     R2 = green

Following the heuristic graph coloring algorithm, show an order in which the nodes can

be eliminate: _____

(3) Add back the nodes and assign colors. Show the colors on the graph from part 1.

(4) Give the final register assignment.

     X: _____

     V: _____

     U: _____

     Y: _____

     W: _____

     Z: _____

Question 22 Given a graph with undirected edges and K colors, we would like to assign to each node a color such that adjacent nodes have different colors. In general, finding such a K-coloring is NP-complete (and can therefore be expected to take exponential

time, depending on the size of the graph). However, a heuristic algorithm works well in practice. Describe this graph-coloring algorithm.

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Question 23 What is "constant folding"?

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Question 24 What is "copy propagation"?

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Question 25 What is "(local and global) common sub-expression elimination"?

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Question 26 What is an "induction variable"?

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Question 27 What is "reduction in strength"?