Please hand in the solutions to the theoretical exercises until the beginning of the next lecture, Wed. 2011-04-27, 10:00. Please write the number of your tutorial group and/or the date/time slot on the first sheet of your solution.

**Exercise 1.1: Control-Flow Graphs (Points: 6)**

Consider the following program $P$:

```plaintext
x = 2;
y = 36;
t = x * 21;
c:
   if(y > 0) {
      y = y - 1;
      t = x * 21;
      goto c;
   }
else {
   x = 5;
   M[0] = x + t;
}
```

Label $P$ and draw its control-flow graph using

- the notation from the Seidl, Wilhelm, and Hack book,
- the notation from the Nielson, Nielson, and Hankin book.

**Exercise 1.2: Available Expressions (Points: 4)**

In Chapter 1.4, a static analysis to compute expressions available in variables was introduced. In Example 1.4.1, we saw a limitation of this analysis w.r.t. its applicability to enable the removal of redundant computations. In order to overcome this particular problem, design a static analysis that computes just the set of available expressions at program points ignoring in which variables they are stored. Design your analysis analogously to the one presented in Chapter 1.4, i.e., give abstract edge effects for all language statements, define path effects, define how information is merged.

**Exercise 1.3: Available Assignments (Points: 6)**

Perform an available assignments analysis on $P$ (see Exercise 1.1). Construct the system of inequations as shown in the lecture or on page 15 in the book and find the least solution.

**Exercise 1.4: Non-Available Expressions (Points: 5)**

Design a static analysis that computes not the available expressions at program points but the (possibly) non-available expressions. Design your analysis from scratch and do not use results from the analysis designed in Exercise 1.2.
Supplementary Question (Points: 1)
Given a program point $p$, let $A[p]$ be the set of available expressions at program point $p$ (as determined by the analysis from Exercise 1.2) and $N[p]$ the set of (possibly) non-available expressions (as determined by the analysis from this exercise). What is the mathematical relation between $A[p]$ and $N[p]$?