

# Final Exam

Each of the five questions is worth six points, for a total of 30 points. Write your name and id number at the top of the first page you submit. Write the solutions for different questions on different sheets of paper. Don't submit this handout.

1. [Type checking] Consider the following Java program:

```
class F {
    public static void main(String[] arg) {
        System.out.println( new C().m(5,6) );
    }
}

class C {
    int x;
    int y;
    public int m(int num, int a){
        int i;
        int j;
        i = 2;
        j = 3;
        if (num < 1) i = 1;
        else      j = num * (this.m(a-1,j-y));
        return i+x;
    }
}
```

Show the symboltable at the point where the type checker will try to type check the expression `new C().m(5,6)`.

2. [Translation] Consider again the Java program from question 1. Make a figure that illustrates a heap layout for a C-object. Present the result of translating the expression

```
System.out.println( new C().m(5,6) );
```

to intermediate code in the style of Piglet, with reasonably detailed comments in the code.

**3. [Arrays]** Consider the Java type `int []` of one-dimensional integer arrays. Make a figure that illustrates the heap layout for such an array. Suppose we have the declaration

```
int [] a;
```

Present the result of translating the array-lookup expression

```
a[3]
```

to intermediate code in the style of Piglet, with reasonably detailed comments in the code.

**4. [Liveness analysis]** Draw the control flow graph for the following program, and show the edges on which each of the variables `a`, `b`, and `c` are live.

```
    a = 0
    b = 5
L1:  if a == 10 then goto L2
    print b
    a = a + 1
    c = 2
    goto L1
L2:  return c
```

**5. [Register allocation]** In the following program, there are six temporaries `a`, `b`, `c`, `d`, `e`, `f`. There are three registers available: `r1`, `r2`, `r3`. Is it possible to do register allocation *without* spilling for this program? Justify your answer.

```
    a = 1
    b = 2
    c = a + 1
    d = a
    e = c + 1
    f = b + e
    return [ d, f live out ]
```