Homework 9

Please submit your solutions via email. Please submit only ASCII text or PDFs. Every solution should be preceeded by the corresponding question text, like:

> **Qn:** ...a difficult question from me...
> **A:** ...an answer from you ...
> **Q$n+1$** ...another difficult question...
> **A:** ...another brilliant answer from you...

Solutions will only be accepted until 20th December! Please send only one homework per email.

1. Describe what is meant by *eliminating tail recursion*? When can this optimization be applied and why is it of benefit?

2. A programming language has arithmetic expression. For an arithmetic expression the compiler of this language produces the following snippet of JVM code.

   ```
   ldc 1
   ldc 2
   ldc 3
   imul
   ldc 4
   ldc 3
   isub
   iadd
   iadd
   ```

   Give the arithmetic expression that produced this code. Make sure you give all necessary parentheses.

3. Describe what the following JVM instructions do!

   ```
   ldc 3
   iload 3
   istore 1
   ifeq label
   if_icmpge label
   ```

4. What does the following LLVM function calculate. Give the

```
define i32 @foo(i32 %a, i32 %b)  {
  %1 = mul i32 %a, %a
  %2 = mul i32 %a, 2
  %3 = mul i32 %2, %b
  %4 = add i32 %1, %3
  %5 = mul i32 %b, %b
  %6 = add i32 %5, %4
  ret i32 %6
}
```

5. **(Optional)** This question is for you to provide regular feedback to me: for example what were the most interesting, least interesting, or confusing parts in this lecture? Any problems with my Scala code? Please feel free to share any other questions or concerns. Also, all my material is ~~crap~~ imperfect. If you have any suggestions for improvement, I am very grateful to hear.