COMP 301: PROGRAMMING LANGUAGES
PROBLEM SET 3

Due date: November 6, 2009 Friday 23:59

Please note:

- In this course, there is a 1 day late policy: You can still submit your homework within 24 hours past the deadline, but will lose 25% of your grade. Anything submitted after that will not be graded.

- Name your file as homework#_Novellname.doc (you can submit docx files as well)
  - Example: hw1_bdevrim.docx

- Submit your homework to: F:\COURSES\UGRADS\COMP\COMP301\HOMEWORK

- For each problem set, your grade will be converted to a plus, half a plus or a minus, based on the following scheme:
  - 100 ≥ grade ≥ 75 → plus
  - 75 > grade ≥ 50 → half a plus
  - 50 > grade ≥ 0 → minus

- Following each problem set, there will be an in class quiz that covers the same material. You can bump up your homework grade if you manage to get a better score in the quiz. Grading for quizzes is the same as the problem sets.

- Any instance of cheating/plagiarism will be referred to the disciplinary committee. All involved parties (e.g., recipient AND the receiver of assistance) will receive an F as their final grade.

Problem 1:\footnote{EOPL, p.54, Exercise 2.27}: Draw the abstract syntax tree for the lambda calculus expressions
((\(a\)) (\(a\) \(b\))) \(c\)

\[(\lambda x)(\lambda y)((\lambda x)(x \ y))\]

Problem 2:\footnote{EOPL, p.70, Exercise 3.4}: Write out the derivation of figure 3.4 as a derivation tree in the style of the one on page 5.

Figure 3.4\footnote{EOPL p.66}:
Let $\rho = [x=33, y=22]$.  

\[
\text{(value-of}
\begin{array}{l}
\langle \text{if zero?(-(x,11)) then -(y,2) else -(y,4)\rangle} \rho \end{array}
\text{)}
\]

\[
= (\text{(if (expval->bool (value-of \langle zero?(-(x,11)\rangle) \rangle} \rho))
\begin{array}{l}
\text{(value-of \langle -(y,2)\rangle \rangle} \rho
\end{array}
\text{)}
= (\text{(if (expval->bool (bool-val #f))}
\begin{array}{l}
\text{(value-of \langle -(y,2)\rangle \rangle} \rho
\end{array}
\text{)}
= (\text{(value-of \langle -(y,4)\rangle \rangle} \rho)
= [18]
\]

Example for a Derivation tree:

\[
\begin{array}{c}
14 \ E \ N \ () \ E \ \text{List-of-Int}
\end{array}
\]
\[
\begin{array}{c}
3 \ E \ N \ (14 . ()) \ E \ \text{List-of-Int}
\end{array}
\]
\[
\begin{array}{c}
-7 \ E \ N \ (3 . (14 . ())) \ E \ \text{List-of-Int}
\end{array}
\]
\[
\begin{array}{c}
(-7 . (3 . (14 . ()))) \ E \ \text{List-of-Int}
\end{array}
\]

**Problem 3:**

Extend the language by adding a new operator minus that takes one argument, $n$, and returns $-n$. For example, the value of \text{minus} \langle -(\text{minus}(5), 9)\rangle should be 14.