CS109B Problem Set #4
Due 4:30 PM, Friday 5/12/95

Because of the exam and project, there is a long gap between problem sets. Therefore, I am counting this as 1.5 sets, with a 150 maximum score. Many of these problems can be worked now, so please try to spread out your work between now and the due date.

1) (30 points)
   a) Construct an ϵ-NFA accepting the same language as regular expression $(a \mid aa)^*$. You **must** use the construction outlined on pp. 573–5, FCS. *Note*: Your answer should have 10 states. If you cannot get this, you should ask someone for help (acknowledging it, of course!) so you can proceed to the next parts.

   b) For your ϵ-NFA of (a), what are the important states?

   c) For your ϵ-NFA of (a), indicate which states are reachable from which states, following only paths (of length 0 or more) of ϵ-labeled arcs.

   d) Convert your answer to (a) to an NFA without ϵ-transitions.

   e) Convert your answer to (d) into a DFA.

2) (20 points)
   a) Start with the NFA of Fig. 10.17 (p. 549). Use the reduction procedure of Section 10.9 to convert it to a 2-state NFA with regular expressions labeling the arcs. Show the labels of all 4 arcs.

   b) Then, give the resulting regular expression whose language is the same as that of the automaton, by applying Formula (10.4) on p. 586.

   c) Simplify your expression from (b) by using algebraic laws of regular expressions.

3) (15 points) Sometimes expressions can have two or more kinds of balanced parentheses. For example, C expressions can have both round and square parentheses, and both must be balanced; that is, every `(` must match a `)`, and every `[` must match a `]`. Write a grammar for strings of balanced parentheses of these two types. That is, you must generate all and only the strings of such parentheses that could appear in well-formed C expressions. (Exercise 11.2.6, FCS)

4) (15 points) On the ith round of Example 11.4 (pp. 599ff, FCS), what is the length of the shortest string that is new for $< S >$? For $< L >$? What is the length of the longest new string for $< S >$? For $< L >$? (Exercise 11.3.2, FCS)

5) (15 points) Using the balanced parenthesis grammars of (a) Fig. 11.3 and (b) Fig. 11.4 (p. 596, FCS), find parse trees for the string `((())())`. (Exercises 11.4.3(c) and 11.4.4(c),FCS)

6) (15 points) The following grammar defines the set of strings (other than ϵ) consisting of `0`'s and `1`'s only.

$$<String> \rightarrow <String><String> \mid \mathbf{0} \mid \mathbf{1}$$

Give an unambiguous grammar that defines the same language. (Exercise 11.5.8, FCS)

7) (15 points) Show the sequence of calls made by the program of Fig. 11.27 (pp. 620–1) on the input `(()())ENDM`. (Exercise 11.6.1(b), FCS)

8) (10 points) Simulate the table-driven parser using the parsing table of Fig. 11.32 (p. 627) on the input string `{s;s}`. (Exercise 11.7.1(d), FCS)

9) (15 points) Suppose we define

```
fun comp F G = G o F;
fun add1 x = x+1;
val compA1 = comp add1;
```

Give the type and value for:

a) `val f = compA1 real;` where `real` is the built-in function that converts integers to equivalent reals.

b) `val compT = comp truncate;` where `truncate` is the built-in function that converts a real to an integer, rounding towards 0 if necessary. (Exercise 21.2(a, b), EMLP) Note that there is a solution to Exercise 21.1 on p. 308, EMLP, which may help you with this problem.