CSE 105: Introduction to the Theory of Computation, Fall 1999
HW4 Due Tuesday, Dec. 7, at the beginning of class

Decidability, Undecidability, **P** and **NP**

1. A grammar G is *context-sensitive* if each rule is of the form $u \to v$, with $\mid u \mid \leq \mid v \mid$. A language is context-sensitive (CS) if it is generated by some context-sensitive grammar. (Note that a CS grammar is more general than a CF grammar.)

   Show that the CS languages are decidable. You may assume that there are no ϵ rules in the CS grammar.

2. Problem 5.4 in text.

3. Show that the following language is undecidable:

   $S_{TM} = \{< M_1, M_2 > \mid M_1$ and M_2 are TM that halt on the same input strings $\}$

4. Show that **NP** is closed under union and concatenation.

5. **Optional, extra credit**
   Show that **P** is closed under complement and intersection.

   Instructions for optional problem: Please hand in on a separate, unattached sheet, with your name and student id. There will be no late optional problems accepted.