1. Problem 8.16, Sipser’s book. \((EQ_{\text{REX}} \text{ belongs to PSPACE.})\)

2. Problem 8.11, Sipser’s book. (Properly nested parantheses is in Logspace)

3. We know that 3SAT is NP-complete, and 2SAT has a polynomial time algorithm. The precise complexity of 2SAT is in fact the class NL, i.e., 2SAT is NL-complete. In this problem, your task is to prove the weaker result that 2SAT is NL-hard.

   (Hint: Give a logspace reduction from PATH to \( \overline{\text{2SAT}} \), and then use NL = coNL. For the reduction, think of a directed edge connecting \( x \) to \( y \) as imposing the constraint \( x \Rightarrow y \).)

4. In the last problem set, you showed that the language \( 3\text{COLOR} \) is NP-complete. We now consider the language \( 2\text{COLOR} = \{ \langle G \rangle \mid G \text{ is an undirected graph that is 2-colorable} \} \).

   Give a logspace reduction from \( 2\text{COLOR} \) to the undirected connectivity problem, specifically the language \( UPATH \), where we define

   \( UPATH = \{ \langle G, s, t \rangle \mid G \text{ is an undirected graph with a path between } s \text{ and } t \} \).

   A very recent breakthrough result from Fall 2004 (and just published in a conference in May 2005) shows that \( UPATH \in L \). Using this together with your reduction, conclude that \( 2\text{COLOR} \in L \).

   (Note that at the same time last year, no one knew whether or not \( 2\text{COLOR} \in L \)!)