1. (20 points) Problem 2.25 in required Textbook.

2. (20 points) Problem 4.2 in required Textbook.

3. (20 points) Problem 4.10 in required Textbook.


5. (20 points) Let $\varphi$ be a 2CNF formula with exactly two literals per clause. Let $x_1, \ldots, x_n$ be the variables in $\varphi$. Associate with $\varphi$ a directed graph $G_\varphi = (V, E)$, where $V = \{x_1, \overline{x}_1, x_2, \overline{x}_2, \ldots, x_n, \overline{x}_n\}$

   (i.e., $V$ is the set of all literals that may appear in $\varphi$), and a pair $(t_1, t_2)$ is an edge in $G_\varphi$ iff $(t_1 \lor t_2)$ is a clause in $\varphi$.

   (a) Show that $\varphi$ is unsatisfiable iff there is a directed cycle in $G_\varphi$ in which both $x_i$ and $\overline{x}_i$ appear, for some variable $x_i$.

   (b) Use part a) to show that $2SAT$ is in $NL$.

   (c) Show that $\overline{PATH} \leq_t 2SAT$. Use this and part b) to show that $2SAT$ is $NL$-complete.