Homework 1
Analysis of Software Artifacts (706)
Due Date: October 2, 2002 (Wed)

Question 1 (Review, 10 points): Please give an English description of the path operators (modalities) and path quantifiers given below. Also express each operator/quantifier in terms of $\mathbf{X}$, $\mathbf{U}$, and $\mathbf{E}$ (use the duality equations here).
Path operators: $\mathbf{X}$, $\mathbf{U}$, $\mathbf{R}$, $\mathbf{F}$, $\mathbf{G}$.
Path quantifiers: $\mathbf{A}$, $\mathbf{E}$.

Question 2 (Review, 40 points):
Part A: Classify each formula given below as $CTL^\star$, CTL, or LTL. Give a short justification for your answer.
$\mathbf{A}(\neg\mathbf{F}p \vee \mathbf{G}q)$, $\mathbf{AG}\ \mathbf{EF}\ \mathbf{AF}p$, or $\mathbf{A}(\neg\mathbf{F}p \vee \mathbf{EG}q)$.

Part B: The path formula $f\mathbf{U_w}g$ ($\mathbf{U_w}$ is called the *weak until*) is true on a path if f remains true until g becomes true, but we *allow g to be false on the entire path*. Express weak until $\mathbf{U_w}$ as a combination of until $\mathbf{U}$ and globally $\mathbf{G}$.

Question 3 (Modeling, 50 points): Express the following English descriptions in $CTL^\star$. Also write the negation of the formula and provide English description of that.

Part A: It is not possible to reach a state that is faulty (where the atomic proposition *faulty* is true).

Part B: If a transaction is started (denoted by truth of the atomic proposition *started*), it always finishes (denoted by the truth of the atomic proposition *finished*).

Things to think about: Down load `NuSMV` from the web-site provided on the course home page. Run the semaphore and vending machine example and analyze the result. Start looking at some examples provided with `NuSMV` distribution.