# Homework 1
# Analysis of Software Artifacts
# Due Date: Oct 4, 2000 (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. Start looking at some examples provided with `NuSMV` distribution.