Exercise 1*: Lecture Evaluation
Complete the lecture evaluation. 1 Bonus Point

Exercise 2: LTL Properties 12 Points
Given the following LTL properties over $AP = \{a, b, c\}$:

\[
\begin{align*}
\varphi_1 &= a \land \Box b \\
\varphi_2 &= a \lor b \\
\varphi_3 &= \neg (a \lor \Box b) \\
\varphi_4 &= (\Diamond c) \lor \Box a \\
\varphi_5 &= \Diamond \Box a \\
\varphi_6 &= \Box \Diamond c
\end{align*}
\]

For each of the LTL properties $\varphi_i$ complete the following tasks:

(a) Give a trace $\tau \in (2^{AP})^\omega$ that satisfies $\varphi_i$.
(b) Give a trace $\tau \in (2^{AP})^\omega$ that violates $\varphi_i$.
(c) State whether or not the transition system below satisfies $\varphi_i$.
(d) Formalize $\text{Words}(\varphi_i)$ (i.e. the set of all traces satisfying $\varphi_i$) using set comprehension.

For example for $\varphi = \Diamond a$ we can formalize $\text{Words}(\varphi) = \{A_0A_1 \cdots | \exists i. a \in A_i\}$.

Exercise 3: Stating properties in LTL 3 Points + 2 Bonus Points
Suppose we have two users, Betsy and Peter, and a single printer device. Both users perform several tasks, and every now and then they want to print their results on the printer. Since there is only a single printer, only one user can print a job at a time. Suppose we have the following atomic propositions for Peter at our disposal:

- Peter.request indicates that Peter requests usage of the printer.
- Peter.use indicates that Peter uses the printer.
- Peter.release indicates that Peter releases the printer.
For Betsy, analogous predicates are defined. Specify in LTL the following properties:

(a) Mutual exclusion, i.e., only one user at a time can use the printer.
(b) Finite time of usage, i.e., a user can print only for a finite amount of time.
(c) Absence of individual starvation, i.e., if a user wants to print something, the user is eventually able to do so.
(d) Bonus: Absence of blocking, i.e., if a user requests access to the printer, the user does not request forever.
(e) Bonus: Alternating access, i.e., users must strictly alternate in printing.

Exercise 4: Equivalence of LTL formulas 8 Points + 2 Bonus Points

Consider the following claims about equivalences of LTL formulas. Provide a counterexample (i.e. a transition system that satisfies one of the properties and violates the other) if an equivalence does not hold.

(a) $\Box a \land \Diamond \Diamond a \nLeftarrow \Box a$
(b) $\Diamond a \land \Box \Diamond a \nLeftarrow \Diamond a$
(c) $\Box a \rightarrow \Diamond b \nLeftarrow a \lor (b \lor \neg a)$
(d) $a \lor false \nLeftarrow \Box a$
(e) $\Box \Diamond b \nLeftarrow \Box b$

Bonus: If an equivalence holds, give a proof.