Exercise 1: LTL
Consider the following transition system over the set of atomic propositions \( \{a, b, c\} \):

Indicate for each of the following LTL-formulas the set of states for which the formula is satisfied.

(a) \( a \land \Box b \)  
(b) \( a \mathcal{U} b \)  
(c) \( \neg(a \mathcal{U} \Box b) \)  
(d) \( \Diamond c \mathcal{U} \Box a \)  
(e) \( \Diamond \Box a \)  
(f) \( \Box \Diamond c \)

Exercise 2: Stating properties in LTL
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:

- \( Peter \text{.request} \) indicates that Peter requests usage of the printer.
- \( Peter \text{.use} \) indicates that Peter uses the printer.
- \( Peter \text{.release} \) 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 3: Equivalence of LTL formulas  
2+2 Points

Consider the following claims about equivalences of LTL formulas.
Provide a counterexample (i.e., instantiate the formula and give a transition system or a word that shows a difference) if an equivalence does not hold.

(a) \((□ \varphi) \land (□ \psi) \nexists □(\varphi \land \psi)\)

(b) \((□ \varphi) \lor (□ \psi) \nexists □(\varphi \lor \psi)\)

(c) \(□ \varphi \rightarrow ◊ \psi \nexists \varphi \mathsf{U}(ψ \lor \neg \varphi)\)

(d) \(□ ◊ \varphi \nexists ◊ □ \varphi\)

Bonus: If an equivalence holds, give a proof.