These are practice problems. You need not turn them in.

Problem 1.1.   Suppose that we defined $\text{STL}^{\forall}$ as:

$$\varphi ::= p \mid \neg\varphi \mid \varphi_1 \vee \varphi_2 \mid \forall \bigcirc \varphi \mid \varphi_1 \forall\mathcal{W}\varphi_2$$

Show that STL can be defined using these primitives.

Problem 1.2.   Is mutual exclusion a safety or a liveness property? What about the property that you should never write to a closed file pointer? What about the following properties: "whenever the server receives a request, it responds" and "whenever the server receives a request, it responds within 10 steps."

Problem 1.3.   Show that a state satisfies $\forall\square\forall\square p$ iff it satisfies $\forall\square p$.

Problem 1.4.   What is the complexity of CTL model checking when you do not have any fairness constraints? Justify your claim with a brief proof.

Problem 1.5.   (This problem is a bit harder than the rest.) Consider the following fragment of STL:
$$\varphi ::= p \mid \neg\varphi \mid \varphi_1 \vee \varphi_2 \mid \exists \bigcirc \varphi$$

Can you express $\exists\lozenge p$ in this fragment? [Hint: Show by induction that two states that are n-step bisimilar agree on all formulas of length at most n.]