Exercise 5.1
Convert the following Büchi automata with transition-based acceptance condition ("doubled"-transitions have to be seen infinitely often) to equivalent Büchi automata with state-based acceptance conditions. Moreover, give a general procedure to perform this conversion.

(a)

```
∅, \{q\}
```

```
1
```

```
\{p\}, \{p,q\}
```

(b)

```
0
```

```
\{q\}, \{p,q\}
```

```
1
```

```
\{p,q\}
```

```
∅, \{p\}
```

```
\{p\}
```

```
\{q\}
```

```
2
```

```
\{q\}
```

```
\∅
```

Exercise 5.2
Extend the set of rules of the LTL to Büchi automata translation to directly deal with the \( F \) and \( G \) operators.

Exercise 5.3
Let \( \phi = G((X(p \ U q)) \rightarrow ((\neg p \land F q) \lor (q \ U X q))) \) and \( G \) be a generalized Büchi automaton translated from \( \phi \) using the construction presented in the lecture and the extended set of rules defined in the previous exercise.

(a) Write down the set of subformulae \( Sub(\phi) \).
(b) What is the size of $CS(\phi)$?
(c) How many sets of accepting states does $\mathcal{G}$ have?
(d) Is $\{\phi\}$ an accepting state of $\mathcal{G}$?
(e) Give a reachable state that has no successors.
(f) Give a successor state of the smallest consistent state containing $\{\phi, q, q \cup X; Fq\}$.
(g) Give a predecessor state of the smallest consistent state containing $\{\phi, q, q \cup X; Fq\}$.

Exercise 5.4
Consider the following Büchi automaton $\mathcal{B}$:

(a) Give an LTL formula $\phi$ such that $\mathcal{L}(\mathcal{B}) = [\phi]$.
(b) By using the result from (a), propose a method to construct a Büchi automaton that accepts the complement of the language accepted by $\mathcal{B}$.
(c) Construct a Büchi automaton for the formula $\mathcal{G}(\neg p \lor (\neg p \text{ R } (p \lor \neg q)))$.
(d) By using the result from (c), construct a Büchi automaton that accepts the complement of the language accepted by $\mathcal{B}$.