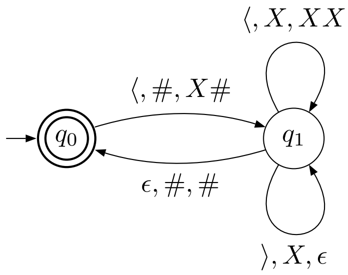
Answer to Exercise 9.1

1. Acceptable answers include:
   - In order to decide this language, we have to keep track of the number of brackets currently open, which cannot be done with finitely-many states.
   - If this were regular, the pumping lemma would allow us to get a contradiction by pumping $\langle$'s into a matched word to obtain a mismatched word that's still in L.

2. The following works:
$$S \to \epsilon \mid \langle S \rangle \mid SS$$

3. We'll use X's on the stack to keep track of the number of open brackets, i.e. $\Gamma = \{X\}$. Put $Z_0 = \#$.



4. Need to show that $(q_0, \langle\langle\rangle\langle\rangle\rangle, \#) \overset{*}{\vdash} (q_0, \epsilon, \gamma)$ for some γ.

$$\begin{aligned}
(q_0, \langle\langle\rangle\langle\rangle\rangle, \#) &\vdash (q_1, \langle\rangle\langle\rangle\rangle, X\#) \\
&\vdash (q_1, \rangle\langle\rangle\rangle, XX\#) \\
&\vdash (q_1, \langle\rangle\rangle, X\#) \\
&\vdash (q_1, \rangle\rangle, XX\#) \\
&\vdash (q_1, \rangle, X\#) \\
&\vdash (q_1, \epsilon, \#) \\
&\vdash (q_0, \epsilon, \#)
\end{aligned}$$

Answer to Exercise 10.3

1.

$$\begin{aligned}
\text{first}(F) &= \text{first}(F\star) \cup \text{first}((R)) \cup \text{first}(a) \cup \text{first}(b) \cup \text{first}(0) \cup \text{first}(1) \\
&= \text{first}(F) \cup \{(\} \cup \{a\} \cup \{b\} \cup \{0\} \cup \{1\} && (F \notin N_\epsilon) \\
&= \text{first}(F) \cup \{(, a, b, 0, 1\}
\end{aligned}$$

The smallest solution to this is $\text{first}(F) = \{(, a, b, 0, 1\}$.

2. Some possible answers:

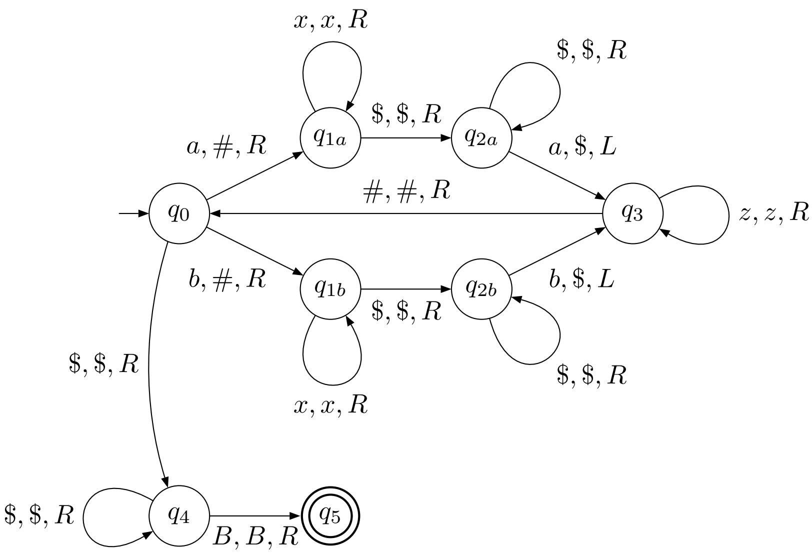
   - Since $a \in \text{first}(F) \cap \text{first}(a)$, the first condition of LL(1) is violated for the F-productions.
   - $(\in \text{first}(R + T) \cap \text{first}(F)$, so the first condition of LL(1) is violated for the R-productions.

3.

$$\begin{array}{lcl}
R & \to & FR' \\
R' & \to & \epsilon \mid +TR' \\
T & \to & FT' \\
T' & \to & \epsilon \mid \bullet FT' \\
F & \to & F'F'' \\
F' & \to & (R) \mid a \mid b \mid 0 \mid 1 \\
F'' & \to & \epsilon \mid \star F''
\end{array}$$

Answer to Exercise 11.4

Letting $x \in \{a, b\}$ and $z \in \{a, b, \$\}$



Then we have the following sequence

$$
\begin{aligned}
(\epsilon, q_0, ab\$ab) &\vdash (\#, q_{1a}, b\$ab) \\
&\vdash (\#b, q_{1a}, \$ab) \\
&\vdash (\#b\$, q_{2a}, ab) \\
&\vdash (\#b, q_3, \$\$b) \\
&\vdash (\#, q_3, b\$\$b) \\
&\vdash (\epsilon, q_3, \#b\$\$b) \\
&\vdash (\#, q_0, b\$\$b) \\
&\vdash (\#\#, q_{1b}, \$\$b) \\
&\vdash (\#\#\$, q_{2b}, \$b) \\
&\vdash (\#\#\$\$, q_{2b}, b) \\
&\vdash (\#\#\$, q_3, \$\$) \\
&\vdash (\#\#, q_3, \#\$\$) \\
&\vdash (\#\#\#, q_0, \$\$) \\
&\vdash (\#\#\#\$, q_4, \$) \\
&\vdash (\#\#\#\$\$, q_4, \epsilon) \\
&\vdash (\#\#\#\$\$B, q_5, \epsilon)
\end{aligned}
$$

Since $q_5 \in F$, conclude $ab\$ab \in L(M)$.