This homework on Sections 4.3 and 4.4 is due Wednesday, April 22.

1. Yet another grammar for expressions involving + and $*$ is shown at the right. (It is from the textbook, page 197.)

$$
\begin{aligned}
E &\longrightarrow E + T \\
E &\longrightarrow T \\
T &\longrightarrow T * F \\
T &\longrightarrow F \\
F &\longrightarrow (E) \\
F &\longrightarrow x \\
F &\longrightarrow y \\
F &\longrightarrow z
\end{aligned}
$$

a) Draw a parse tree for the expression $x * y + z$, using this grammar.

b) Draw a parse tree for the expression $(x + y) * z + x * y$, using this grammar.

c) Find a left derivation for the expression in part b), using this grammar.

2. The grammar at the right generates the language $\{a^n b a^m \mid m > n\}$.

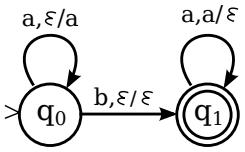
$$
\begin{aligned}
S &\longrightarrow aSA \\
S &\longrightarrow b \\
A &\longrightarrow aA \\
A &\longrightarrow a
\end{aligned}
$$

a) Show that this grammar is ambiguous by finding a string in the language that has two parse trees, or two left derivations. If you use parse trees, you should draw two parse trees for your string; if you use left derivations, you should give two left derivations for your string.

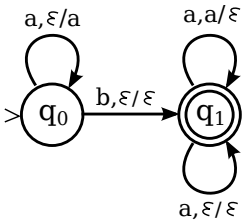
b) Give an unambiguous grammar for the same language. you do not have to prove that your grammar is unambiguous.

3. Find the language that is accepted by each of the following pushdown automata. **Explain your reasoning** by describing how the machine works when accepting a string in the language.

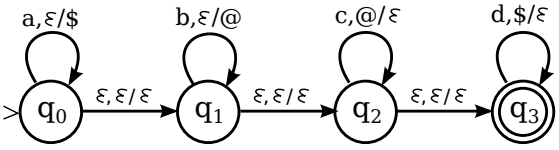
a)



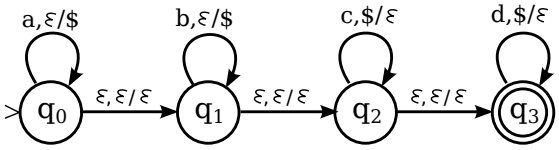
b)



c)



d)



4. Draw a transition diagram for a pushdown automaton that accepts the language $L = \{a^n b^m a^n \mid n, m \in \mathbb{N} \text{ and } m > 0\}$. Explain how your machine works.