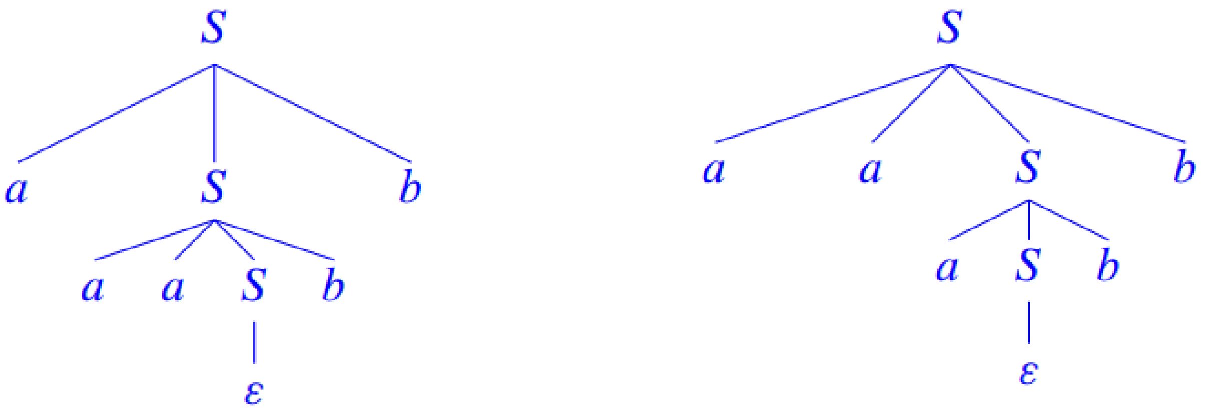
1.

a. The string $aaabb$ has two parse trees:



2.

ANS:

Using the algorithm from the lecture, we get the grammar $G' = (V', \Sigma, R', S)$ with $V = \{S, X, X_1, X_2, Y, A, B, C\}$, $\Sigma = \{a, b, c\}$, and R' being the following set of rules:

$$
\begin{aligned}
S_0 &\to S \\
S &\to XY \\
X &\to abb \mid aXb \mid \epsilon \\
Y &\to c \mid cY
\end{aligned}
$$

$$
\begin{aligned}
S_0 &\to S \\
S &\to XY \mid Y \\
X &\to abb \mid aXb \mid ab \\
Y &\to c \mid cY
\end{aligned}
$$

$$
\begin{aligned}
S_0 &\to S \\
S &\to XY \mid c \mid cY \\
X &\to abb \mid aXb \mid ab \\
Y &\to c \mid cY
\end{aligned}
$$

$$
\begin{aligned}
S_0 &\to S \\
S &\to XY \mid c \mid cY \\
X &\to aX_1 \mid aX_2 \mid ab \\
X_1 &\to bb \\
X_2 &\to Xb \\
Y &\to c \mid cY
\end{aligned}
$$

$$
\begin{aligned}
S &\to XY \mid c \mid CY \\
X &\to AX_1 \mid AX_2 \mid AB \\
X_1 &\to BB \\
X_2 &\to XB \\
Y &\to c \mid CY \\
A &\to a \\
B &\to b \\
C &\to c
\end{aligned}
$$

3.

ANS:

$$
\begin{aligned}
&(aaadbabacc, q_0, \epsilon) \to \\
\to&(aaadbabacc, q_1, \$) \to \\
\to&(aadbabacc, q_1, x\$) \to \\
\to&(aadbabacc, q_2, x\$) \to \\
\to&(adbabacc, q_2, yx\$) \to \\
\to&(dbabacc, q_2, yyx\$) \to \\
\to&(babacc, q_3, yyx\$) \to \\
\to&(abacc, q_4, yyx\$) \to \\
\to&(bacc, q_3, yx\$) \to \\
\to&(acc, q_4, yx\$) \to \\
\to&(cc, q_3, x\$) \to \\
\to&(cc, q_5, x\$) \to \\
\to&(c, q_6, x\$) \to \\
\to&(\epsilon, q_5, \$) \to \\
\to&(\epsilon, q_7, \epsilon).
\end{aligned}
$$

4.

ANS:

Assume L is context-free. Then by the pumping lemma, there is a number p.

Let $s = 0^p 1^{p+1} 0^p$. The length $|s| = 3p + 1 > p$. By the lemma, s can be rewritten as

$$w = uvxyz, \quad \text{for some } u, v, x, y, z \in \{0, 1\}^*$$

and $|vxy| \leq q$ and $|vy| > 0$

Case 1: vy consists of entirely 0s. Both v and y have to belong to the same group of 0s in s (either the prefix 0^p or the suffice 0^p). By the lemma the pumped string $uv^2xy^2z \in L$. However, the pumped string has the prefix 0s and suffice 0s out of balance; thus it does not belong to L. Contradiction.

Case 2: vy consists of entirely 1s. Both v and y have to belong to the group 1s in s. By the lemma the pumped string $uv^0xy^0z = uxz \in L$. However, the pumped string has at most p number of 1s; thus it does not belong to L. Contradiction.

Case 3: vy consists of mixed 0s and 1s.

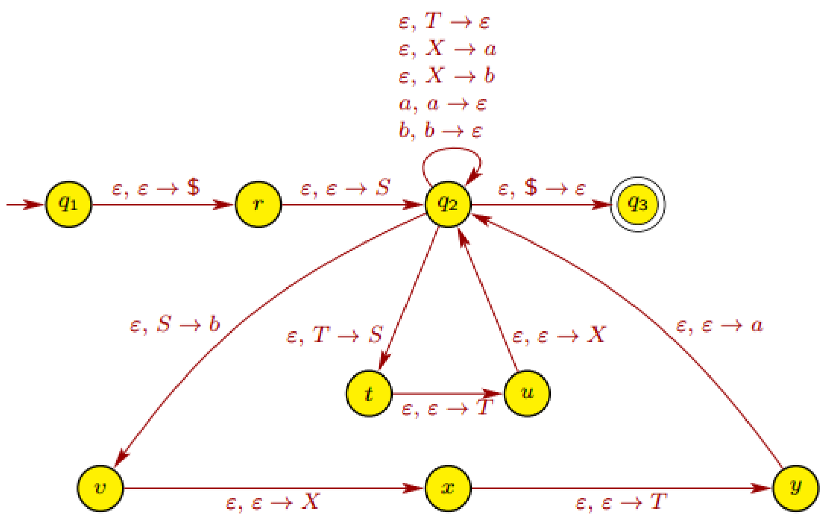
(a) If either v or y consists mixed 0s and 1s, by the lemma pumped string $uv^2xy^2z \in L$. But it contains the interleaving 0s and 1s then 0s and 1s, not in the format of 0s and 1s and then 0s; thus not belong to L. Contradiction.

(b) If v consists of only 0s and y consists of 1s (or the other way around), by the lemma pumped string $uv^2xy^2z \in L$. However, the prefix 0s and suffix 0s in the pumped string are out of balance; thus it does not belong to L. Contradiction.

Since in all the scenarios, we have logic contradiction, the assumption that L is context-free was incorrect. Therefore, we proved that L is NOT context-free.

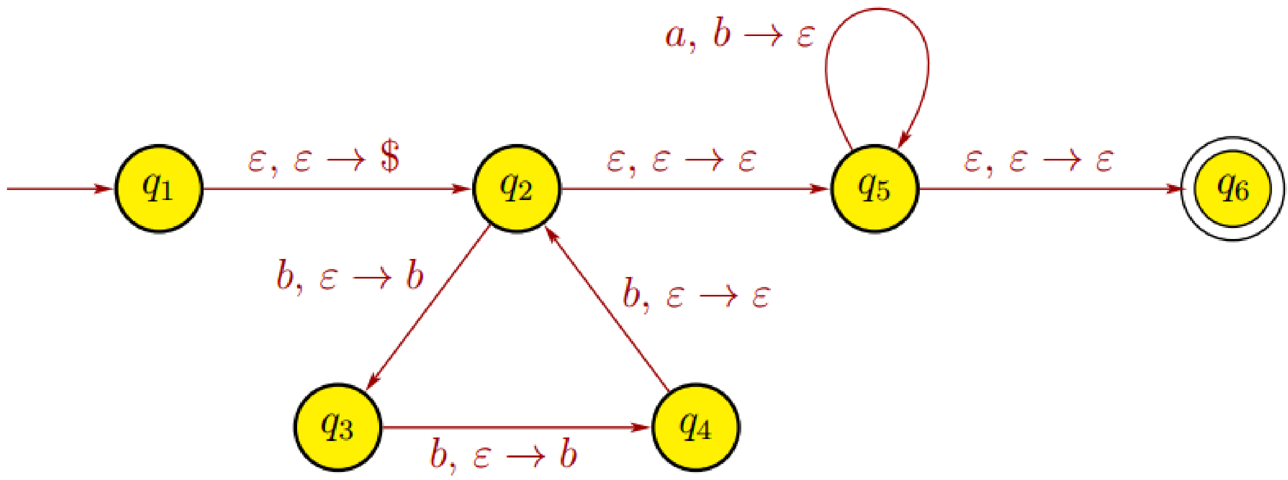
5.

ANS :



6.

Ans :



7.

ANS

1.

a) first(A)={a,c,ε} first(B)={c,ε} first(C)={a,c,d}

b) follow(A)={a,b,c} follow(B)={a,b,c} follow(C)={ε}

c)

	a	b	c
A	5,6	5	5
B	3	3	3,4
C	2	1,2	2

d) No. Some entries in the parse table consist of multiple rules.