$R \longrightarrow XRX \mid S$
$S \longrightarrow aTb \mid bTa$
$T \longrightarrow XTX \mid X \mid \varepsilon$
$X \longrightarrow a \mid b$

1.1) What are the variables of G?
- R,S,T,X

1.2) What are the terminals of G?
- a,b

1.3) Which is the start variable of G?
- R

1.4) Give three strings in L(G)
- Abba
- Baaabb
- Aaabbaaa

1.5) Give three strings NOT in L(G)
- Abbaa
- Babab
- Ababab

1.6) For the following derivations, circle True or False.
- $T \Rightarrow aba$ **True**
- $T \ast\Rightarrow aba$ **True**
- $T \Rightarrow T$ **True**
- $XXX \ast\Rightarrow aba$ **False**
- $X \ast\Rightarrow aba$ **False**
- $T \ast\Rightarrow XX$ **True**
- $T \ast\Rightarrow XXX$ **True**
- $S \ast\Rightarrow \varepsilon$ **True**

2. [5 pts] Give context free grammas that generate the following languages. Alphabet Σ = {0, 1}.

2.1) L = {ω | ω *contains at least three* 1*s*}
S -> 0S1 | ε

2.2) L = {ω | ω *starts and ends with the same symbol*}
S -> 0S0 | 1S1 | ε

2.3) L = {ω | *the length of* ω *is odd*}
S -> 0S0 | 1S1 | ε

2.4) L = {ω | *the length of* ω *is odd and its middle is a* 0}
S -> 0S0 | 1S1 | ε
A -> 0A | 1A

2.5) L = {ω | $\omega = \omega R$, *that* ω *is a palindrome*}
S -> aSa | bSb | ε

3. [5 pts] Give CFG that generates the language $A = \{aibjck \mid i = j \text{ or } j = k \text{ where } i, j, k \geq 0\}$. Is your grammar ambiguous? Why or why not?

S -> XcY | a S c | ε
X -> aXb | ε
Y -> cYb | ε

This CFG generates strings where the counts of 'a's, 'b's, and 'c's are equal. It is not ambiguous because there is only one way to derive each string, and the rules are unambiguous. The CFG ensures that for each 'a' added, there is a corresponding 'b', and for each 'b' added, there is a corresponding 'c', making it impossible for ambiguity to occur.