1. (4 points total) Consider the NFA N1:

Use a regular expression to capture the language recognized by N1. (This may be tricky!)

\((0U1)^*1\)

Also: \((0U1)^*1 (0(0U1)^*1)^*\)

2. (5 points) Use a Context Free Grammar to express the language

L2= \{w | w=0^n11 and n \geq 1\} (Words in language L2 include 11, 011, 00011, etc.)

S -> A11
A -> A0 | 0
3. (5 points total) Consider the language $L_3$ in alphabet $\Sigma = \{0,1\}$ described by the following regular expression: 

$$L_3 = 1^*(0 \cup 1)(01)^*$$

Provide three strings in the language $L_3$.

0, 1, 10, 11, 001, 101, 110, 111, 1001, 1101, 1001, 1110, 1111, ...
4. (5 points) Let us consider the regular language \( L_4 = \{ w \mid w \in (012)^*221 \} \).

a. (3.5 points) We attempt to show \( L_4 \) is **not** regular by considering the word \( w = 012221 \). If we assign \( x = 01 \), \( y = 222 \), and \( z = 1 \), \( xy^2z \) is not in \( L_4 \), and therefore we argue that \( L_4 \) is not a regular language. What is a problem with this argument?

Before we can conclude \( w \) is not pumpable, we must be sure there is no way to split it into \( xyz \) such that \( xy^iz \) will not be in \( L_4 \). However, if \( x = \varepsilon \), \( y = 012 \), and \( z = 221 \) \( xy^iz \) **WILL** be in \( L_4 \). One bad choice of \( y \) does not disprove the existence of a good choice for \( y \).

b. (1.5 points) What is the pumping length of \( L_4 \)?

6 (the smallest pumpable string is 012221)