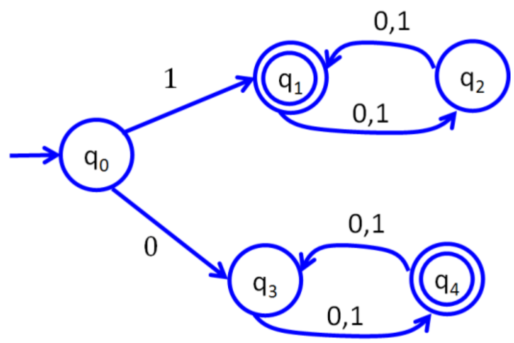
1. Consider the state diagram for the following DFAs. For each, answer the following questions:

(1) What state is reached by the input: w=00110 ?

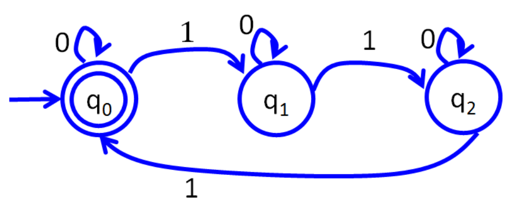
(2) What is the transition function?

(3) What is the language recognized?

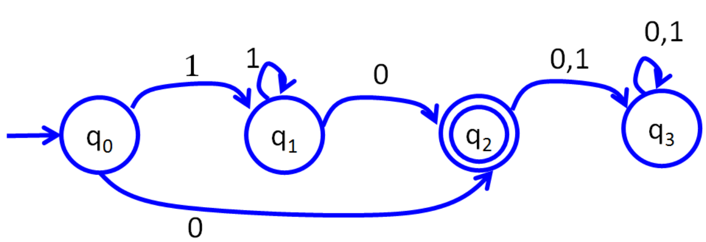
M1:



M2:



M3:



2. Define a machine to recognize the following languages in the alphabet
$\Sigma = \{1,2,3\}$
(5 points)

**L4={w | the product of input symbols is even}   E.g., 111->1x1x1=1 is odd-reject,
233 -> 2x3x3 = 18 is even-accept**

L5={w | numbers entered in non-decreasing order}   Examples: 112223, 122333

L6={w | first two symbols are identical}   Examples: 001213, 333212, 3310013

3. Prove the following languages are regular, using the alphabet $\Sigma = \{a, b, c\}$:

L7={w | w contains an odd number of b's}

L8={w | w contains the sequence bcb} (Examples: aabbbcbb or ccbcba)

L9={w | w does not have three a's in a row}

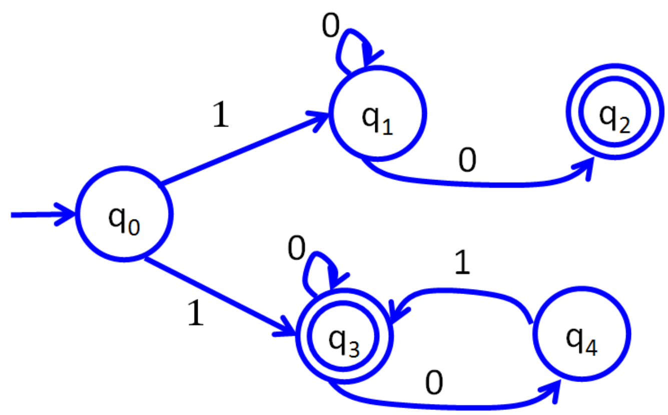
4. Consider the following NFAs. For each, answer:

(1) what state(s) will be reached by the input: 0011

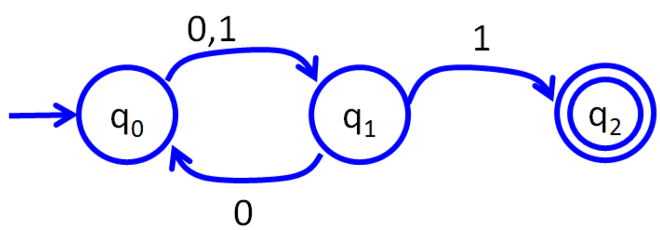
(2) provide a regular expression to describe the recognized language

(3) **For N11 and N12**, convert NFA to DFA

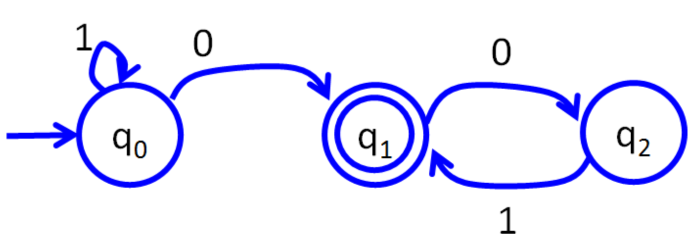
N10:



N11:



N12:



5. For each regular expression using $\Sigma = \{a, b\}$:
(1) Provide three example words.
(2) Convert these regular expressions to a DFA or NFA

L13={$\mathbf{ab^*(ba)^*}$}

L14={$\mathbf{(a \cup b)ba^*}$}

L15={$\mathbf{(bb)^* \cup (aa)^*}$}

6. What is the minimum pumping length for each of these languages, showing these languages are regular? We use the alphabet $\Sigma = \{0,1,2\}$

L16={$\mathbf{00(0 \cup 1)^*12}$}

L17={$\mathbf{0(22)^*10}$}

L18={$\mathbf{111(202)^*210}$}

If pumping length is p=5, how would you break up string w into x, y, and z for languages L below?

L19={ $20(11)^*001$ }, w=201111001

L20={ $(121)^*001$ } w=121001

7. Consider the language L21 ={01(101)*11}, what is the error in each of the following “pumping lemma” arguments?

Argument 1: Let us take w=0111, $\mathbf{w \in L21}$. We cannot divide w=xyz such that $\mathbf{y^i z \in L21, i \geq 0}$. For example, if x=0, y=11, and z=1, xy^2z = 011111$\notin$ $\mathbf{L21}$. Therefore, L21 is not regular.

Argument 2: Let us take w=0110110111, $\mathbf{w \in L21}$. If we divide w=xyz as follows: x=0110110 , y=11, z=1, we cannot repeat y such that $\mathbf{xy^i z \in L21, i \geq 0}$. For example, if xy^2z = 011011011111$\notin$ $\mathbf{L21}$. Therefore, L21 is not regular.

8. Prove these languages are not regular.

L24={$0^n1^{2n}0^{3n}$ | n>0 }

L25={1^{n^3} |n>0}

9. For each of the following grammars, list three strings produced by the grammar

G26:
S -> AB | BA
A -> xAy | ε
B -> BzB | y

G27:
S -> A | AA
A -> 00 | 11

G28:
A -> 11A00 | ε

10. Provide the languages described by two of the grammars:

G27 (from above)

G28 (from above)

10. Provide a grammar to produce the following languages

L32 = $\{0^n(11)^n \mid n \geq 0\}$

L33 = $\{01^*00^*\}$

L34 = $\{w \mid w = w^{Reverse}\}$ **Examples: 00100, 10101, 1111**

11. Convert the following grammars to Chomsky Normal Form

G29:

S -> xAy | BA

A -> z | AzA

B -> yB | ε

G30:

S -> BAB | ABA

A -> y | z

B -> x | AA | ε

G31:

S-> ByBy

B -> xBx | ε