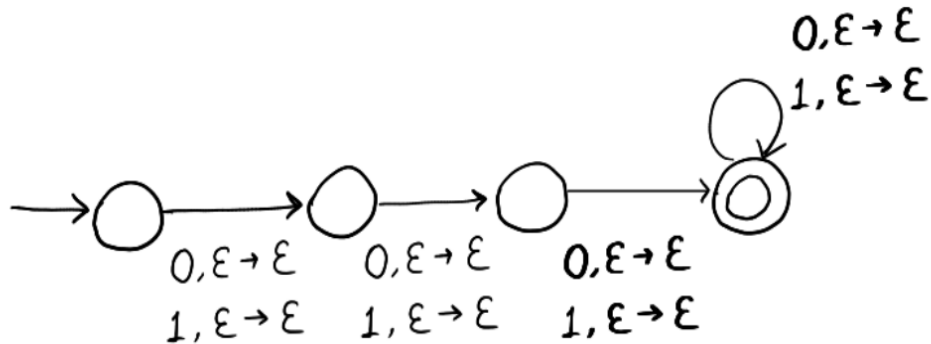
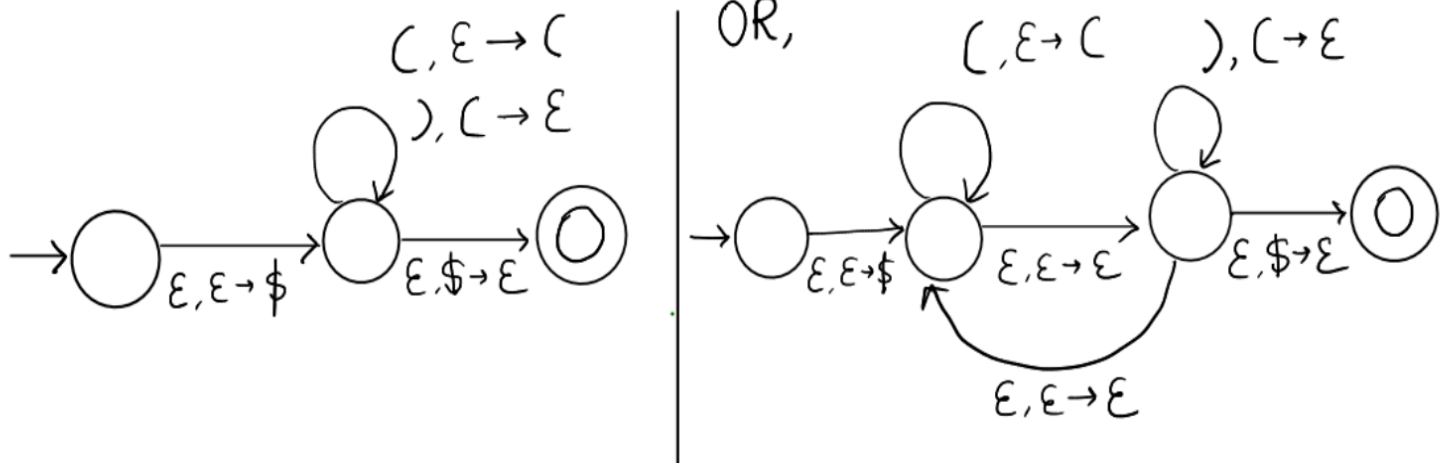


Construct Pushdown Automata for the following languages.

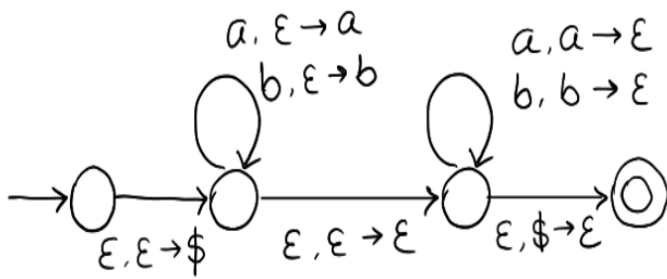
a)  $L = \{w \in \{0,1\}^* : \text{length of } w \text{ is at least three.}\}$  [Hint: Recall what kind of language  $L$  is.]



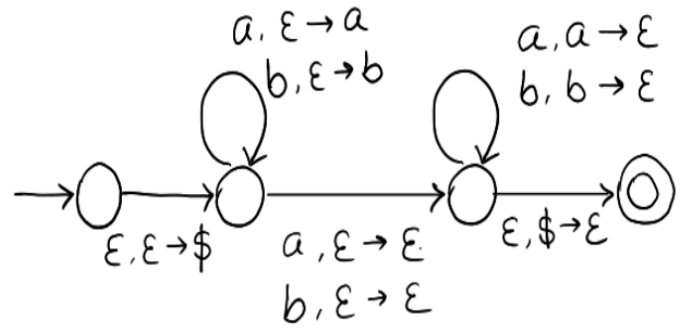
b)  $L = \{w \in \{(, )\}^* : w \text{ is a valid parenthesis}\}$



c)  $L = \{w \in \{a, b\}^*: w \text{ is a even length palindrome}\} / L = \{w \in \{a, b\}^*: w \text{ is a odd length palindrome}\}$



### even Length Palindrome



### odd Length Palindrome

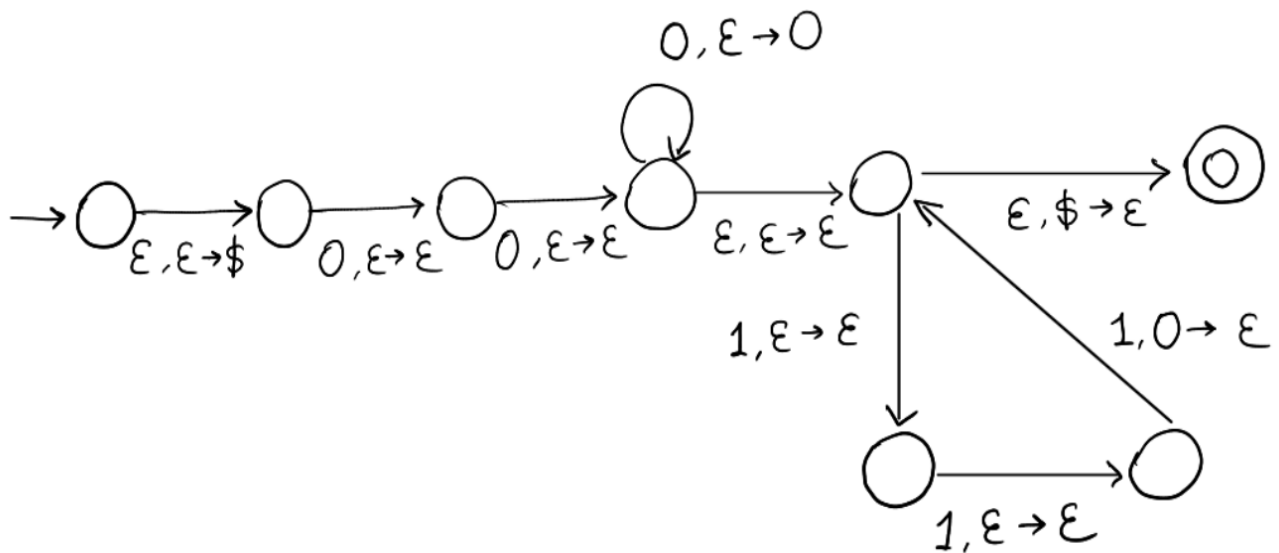
d)  $L = \{w \in \{0, 1\}^*: 0^{n+2}1^{3n}, \text{ where } n \geq 0\}$

$$O^{n+2} \quad O^1 \Rightarrow O^2 \quad O^0 \quad O^1$$

$$n = 0 : 00$$

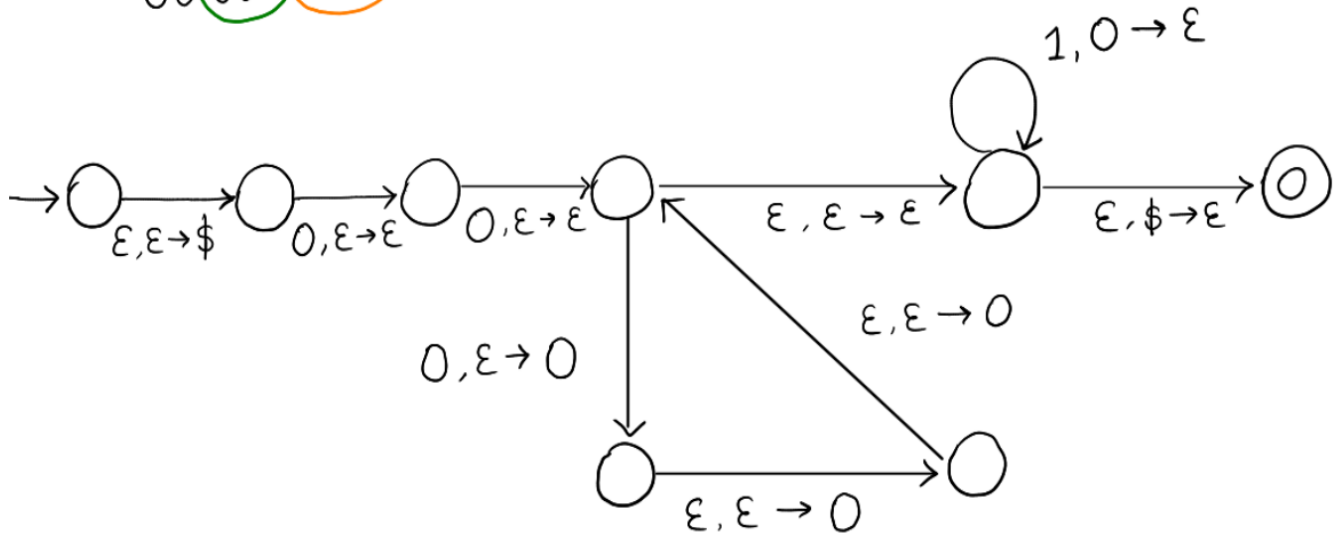
$$n = 1 : 000111$$

$n=2$  : 00 00 111 111



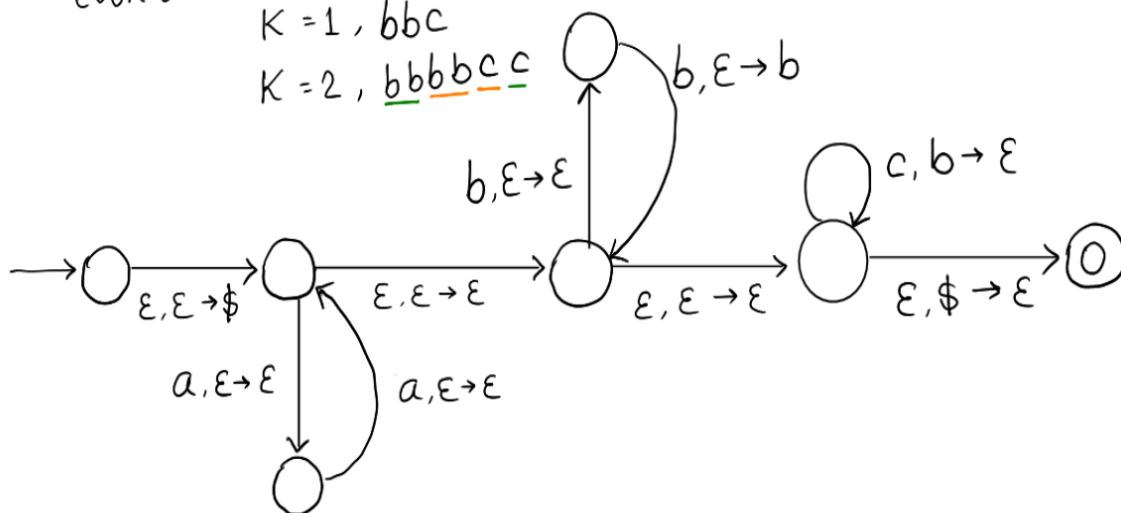
e)  $L = \{w \in \{0, 1\}^*: 0^{n+2}1^{3n}, \text{ where } n \geq 0\}$  [Alternate Solution Idea]

$n=2$ , 0000 111 111  
 00 000 000 111 111



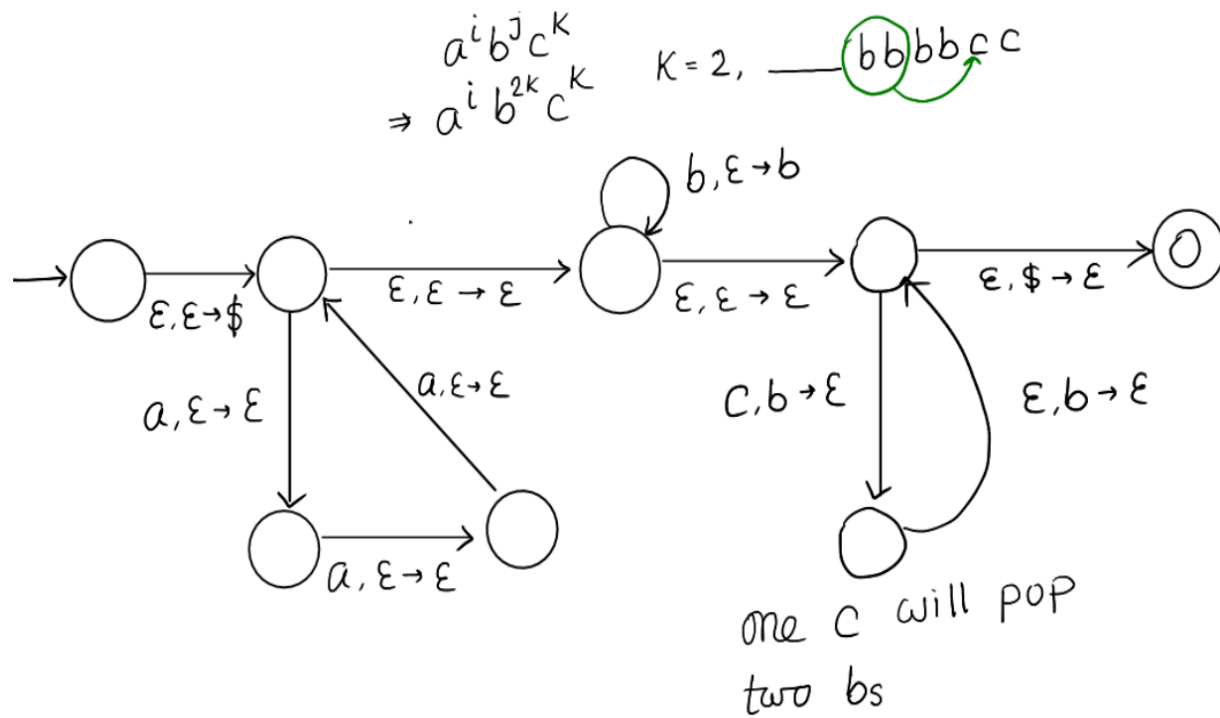
f)  $L = \{w \in \{a, b, c\}^*: a^i b^j c^k, \text{ where } i \text{ is even, } j = 2k \text{ and } i, j, k \geq 0\}$

$a^i b^j c^k, j=2k$   
 $\Rightarrow a^i b^{2k} c^k$   
 even  $a$   $\downarrow$   $\downarrow$   
 $K=0, \epsilon$   
 $K=1, b b c$   
 $K=2, \underline{b b b} \underline{b c c}$

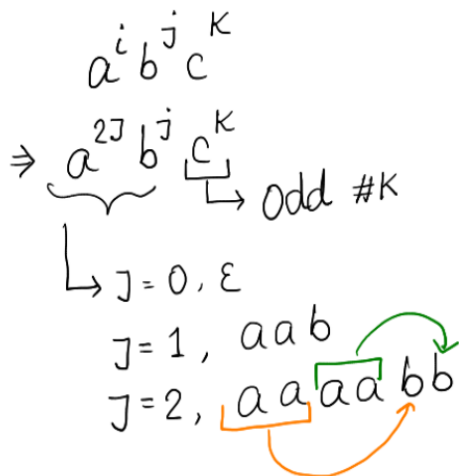


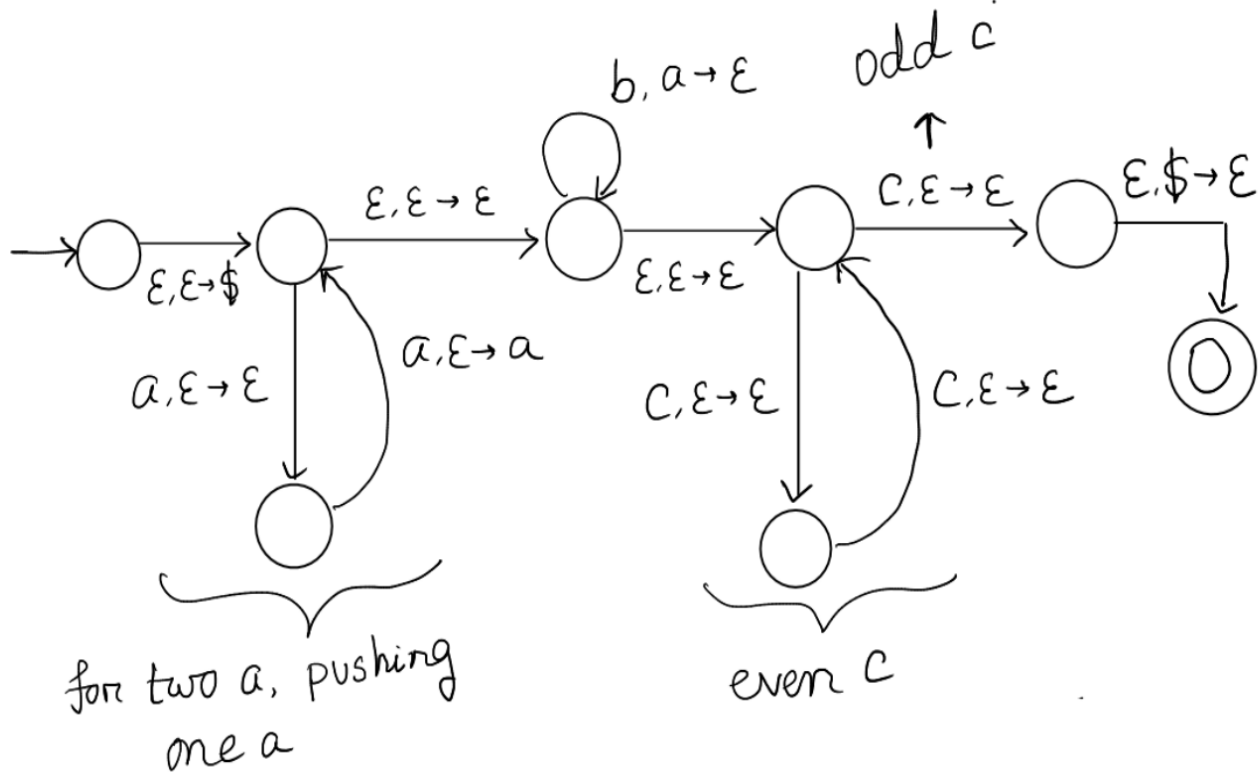
g)  $L = \{w \in \{a, b, c\}^*: a^i b^j c^k, \text{ where } i \text{ is multiple of three, } j = 2k \text{ and } i, j, k \geq 0\}.$

Same as the previous question, an alternate way to handle  $j=2k$

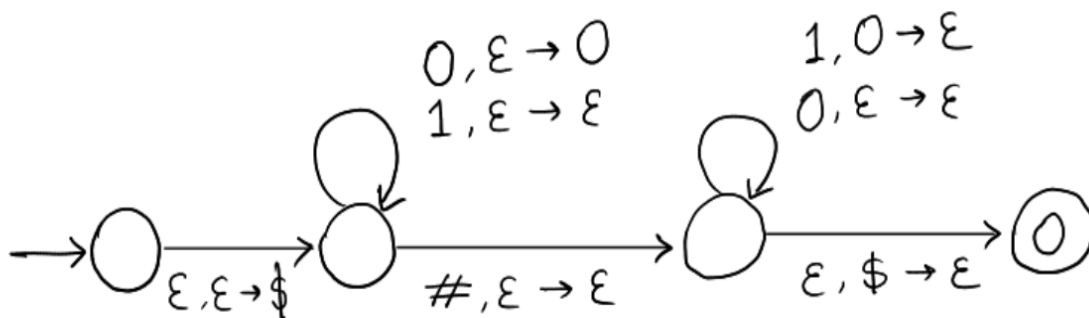


h)  $L = \{w \in \{a, b, c\}^*: a^i b^j c^k, \text{ where } k \text{ is odd, } i = 2j \text{ and } i, j, k \geq 0\}.$

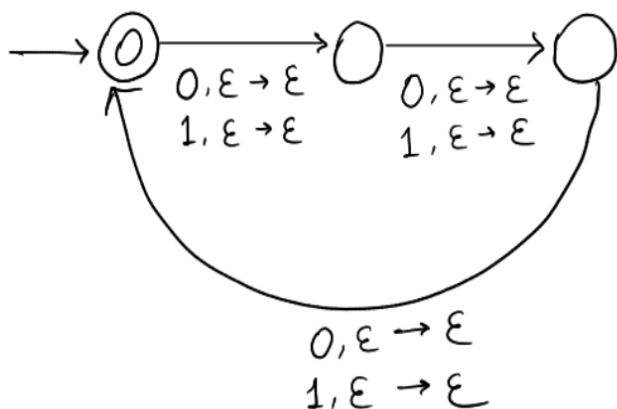




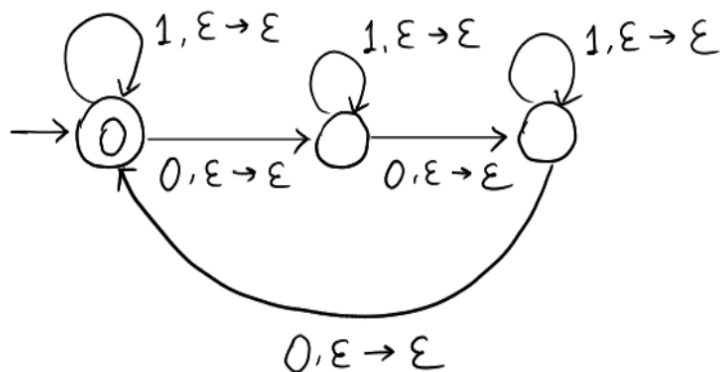
i) Let  $\Sigma = \{0, 1, \#\}$ .  $L = \{w_1\#w_2 \mid \text{number of 0s in } w_1 \text{ is equal to number of 1s in } w_2\}$



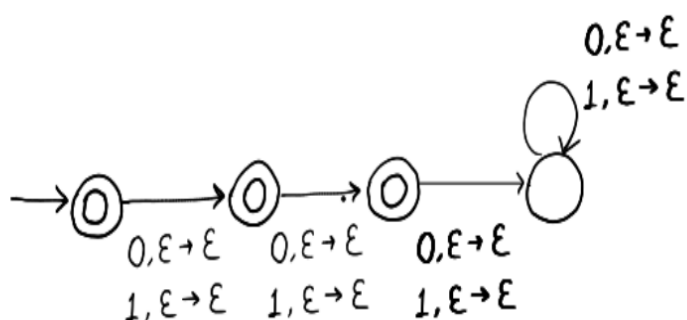
j)  $L = \{w \in \{0,1\}^* : \text{length of } w \text{ is a multiple of three}\}$  [Hint: Recall what kind of language L is.]



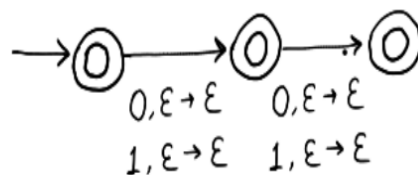
k)  $L = \{w \in \{0,1\}^* : \text{number of 0s in } w \text{ is a multiple of three}\}$  [Hint: Recall what kind of language  $L$  is.]



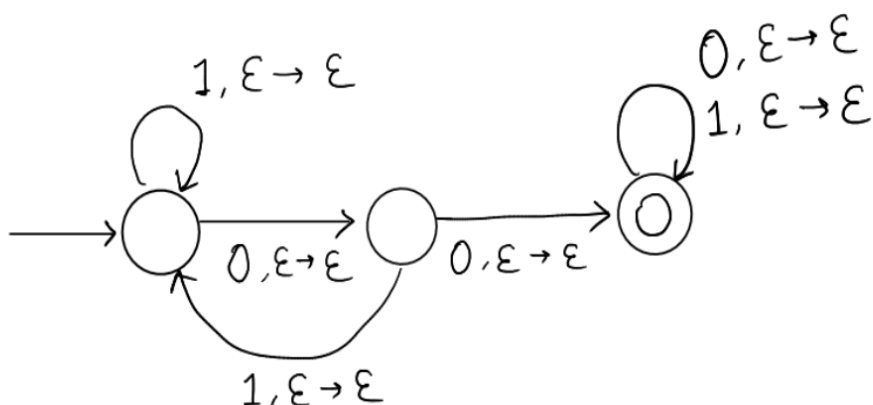
l)  $L = \{w \in \{0,1\}^* : \text{length of } w \text{ is at most two.}\}$  [Hint: Recall what kind of language  $L$  is.]



or,



m)  $L = \{w \in \{0,1\}^* : w \text{ contains } 00 \text{ as a substring}\}$ . Construct a PDA for  $L$ . [Hint: Recall what kind of language  $L$  is.]



n)  $L = \{ w\#x : w, x \in \{a, b\}^* \text{ and } x \text{ contains } w^R \text{ as a substring} \}$ . [Recall: For a string  $w$ ,  $w^R$  denotes  $w$  in reverse order.]

