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UNIVERSITY  
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# THEORY OF AUTOMATA AND FORMAL LANGUAGES

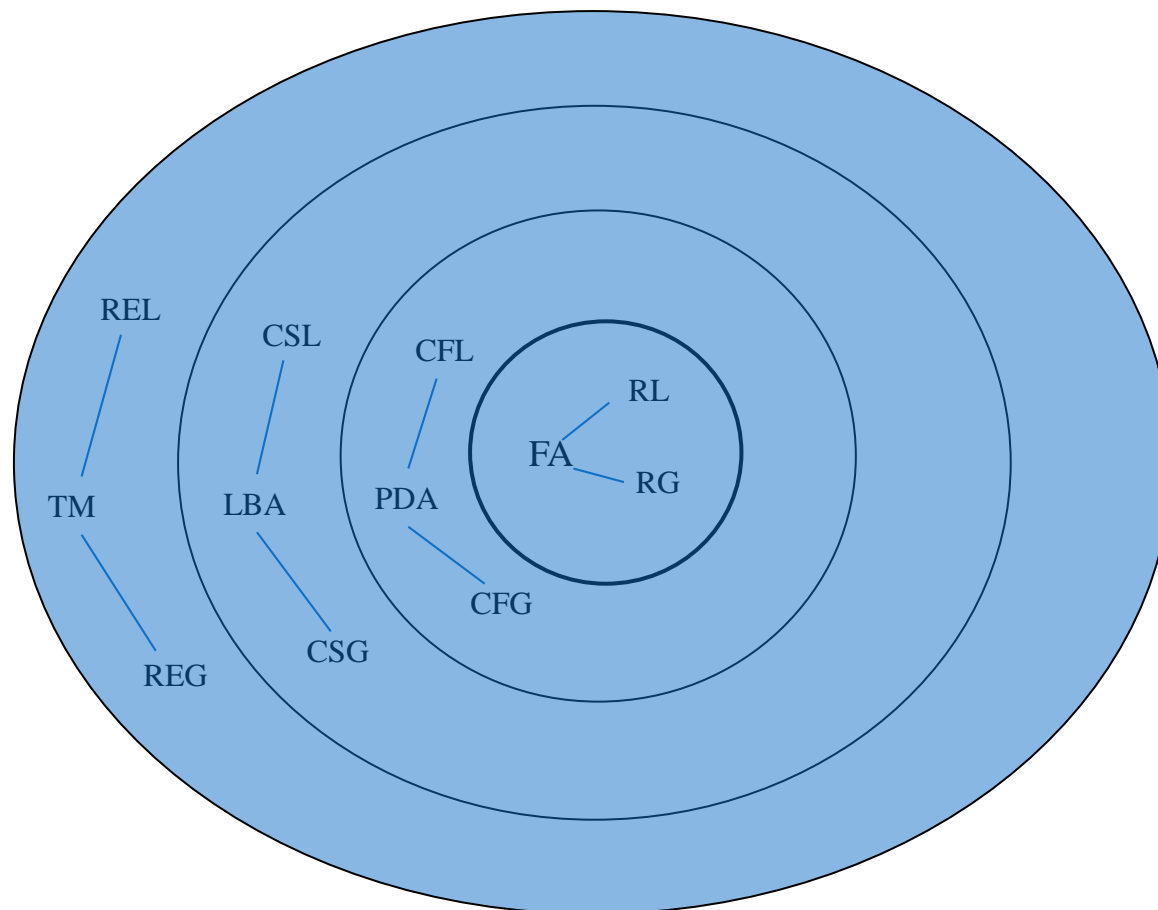
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LECTURE: TURING MACHINE

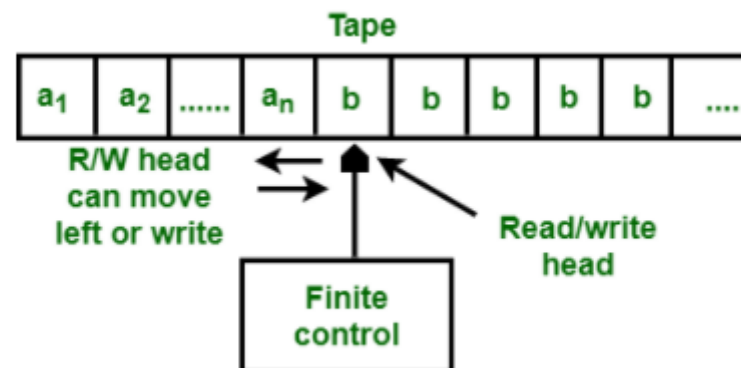
-By Nishtha Parashar

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# TURING MACHINE

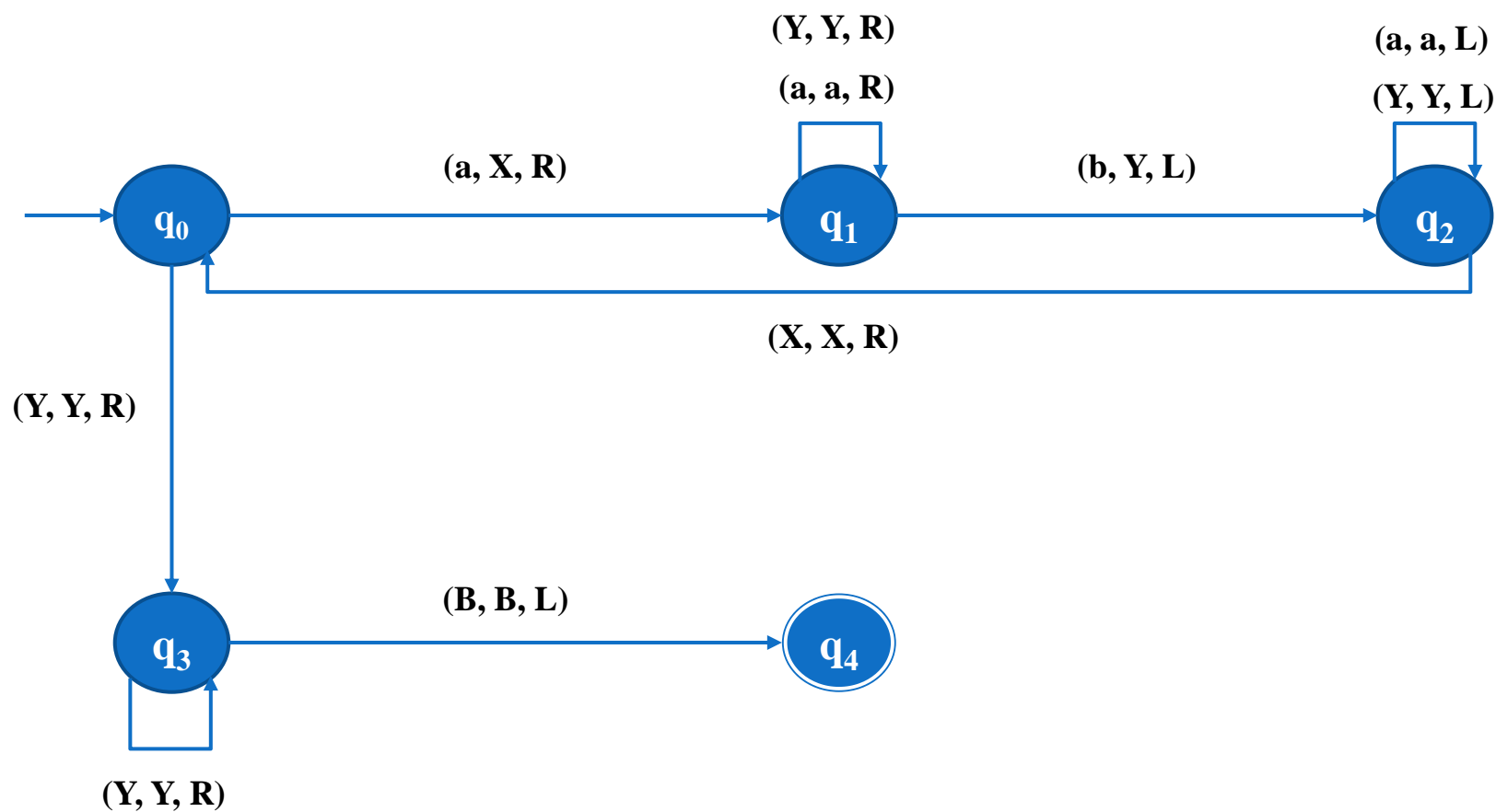
- Turing Machine was invented by Alan Turing in 1936 and it is used to accept Recursive Enumerable Languages (generated by Type-0 Grammar).
- A turing machine consists of a tape of infinite length on which read and writes operation can be performed.
- The tape consists of infinite cells on which each cell either contains input symbol or a special symbol called blank. It also consists of a head pointer which points to cell currently being read and it can move in both directions.



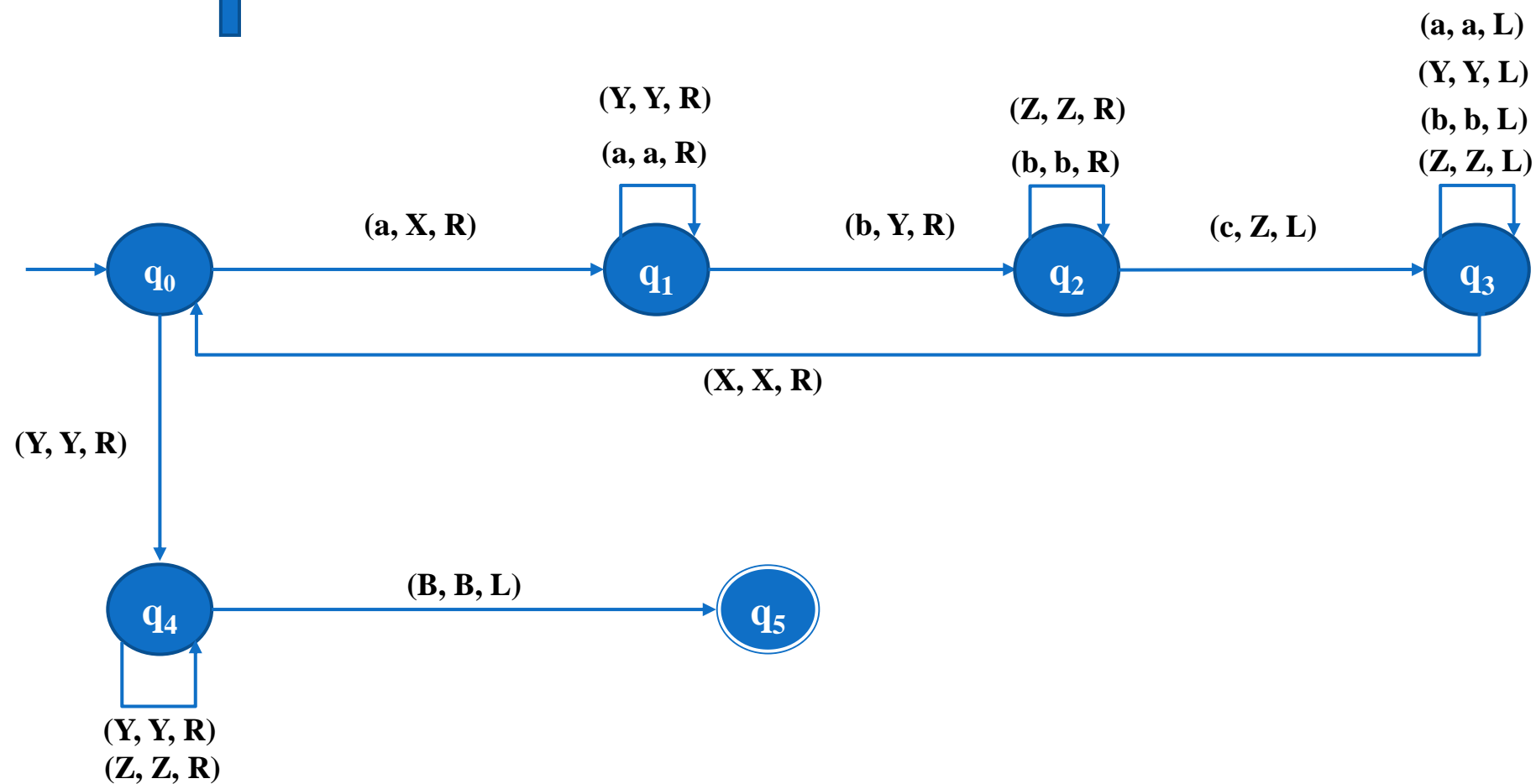
$$a^n b^n / n \geq 1$$



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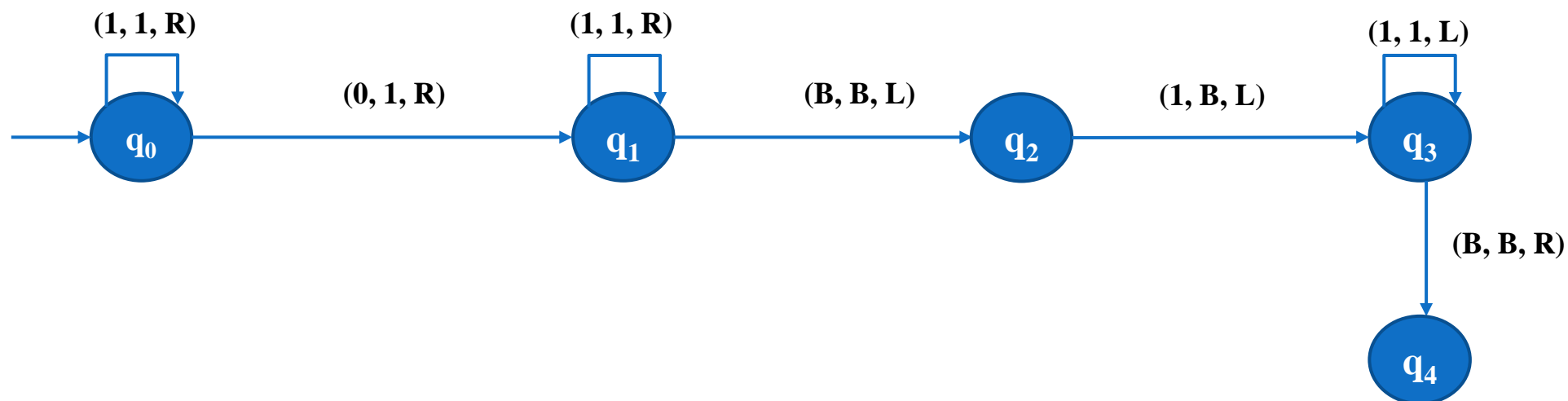
$$a^n b^n c^n / n \geq 1$$



# Turing Machine as Adder

Question: Add 3 + 4

3 = |111| , 4 = |1111|

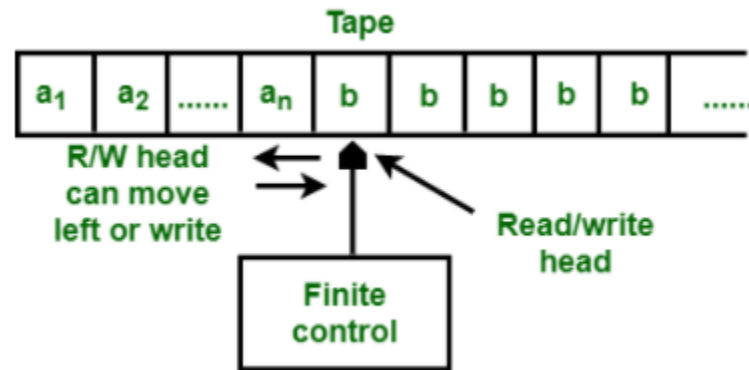


# Turing Machine as Copier

String: 111

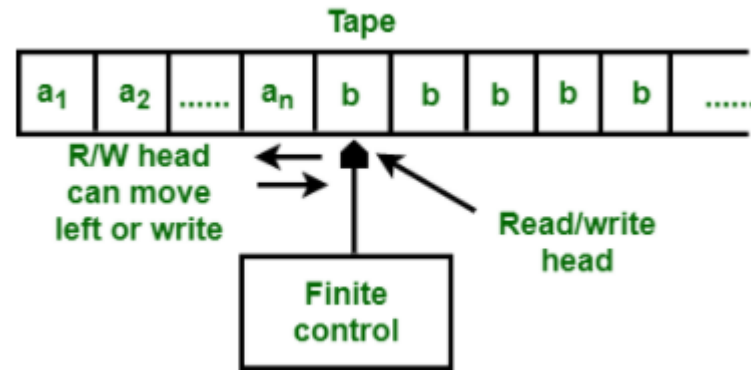
B	B	B	1	1	1	B	B	B
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A TM is expressed as a 7-tuple  $(Q, T, B, \Sigma, \delta, q_0, F)$  where:

- **Q** is a finite set of states
- **T** is the tape alphabet (symbols which can be written on Tape)
- **B** is blank symbol (every cell is filled with B except input alphabet initially)
- $\Sigma$  is the input alphabet (symbols which are part of input alphabet)
- $\delta$  is a transition function which maps  $Q \times T \rightarrow Q \times T \times \{L, R\}$ . Depending on its present state and present tape alphabet (pointed by head pointer), it will move to new state, change the tape symbol (may or may not) and move head pointer to either left or right.
- **q<sub>0</sub>** is the initial state
- **F** is the set of final states. If any state of F is reached, input string is accepted.



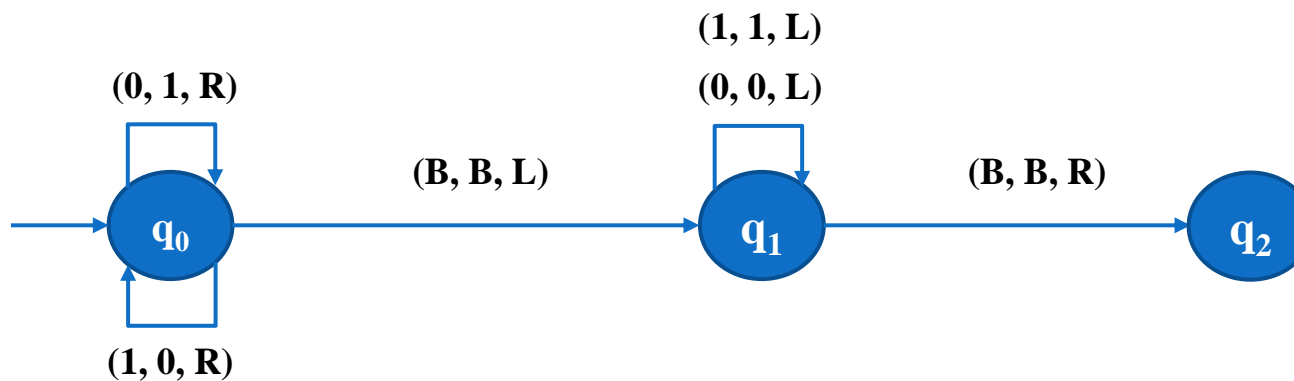
### Summary:

1. Tap is unbounded, so any number of left and right moves are possible.
2. It is deterministic i.e. atmost one move for each configuration.
3. No special input or output file.

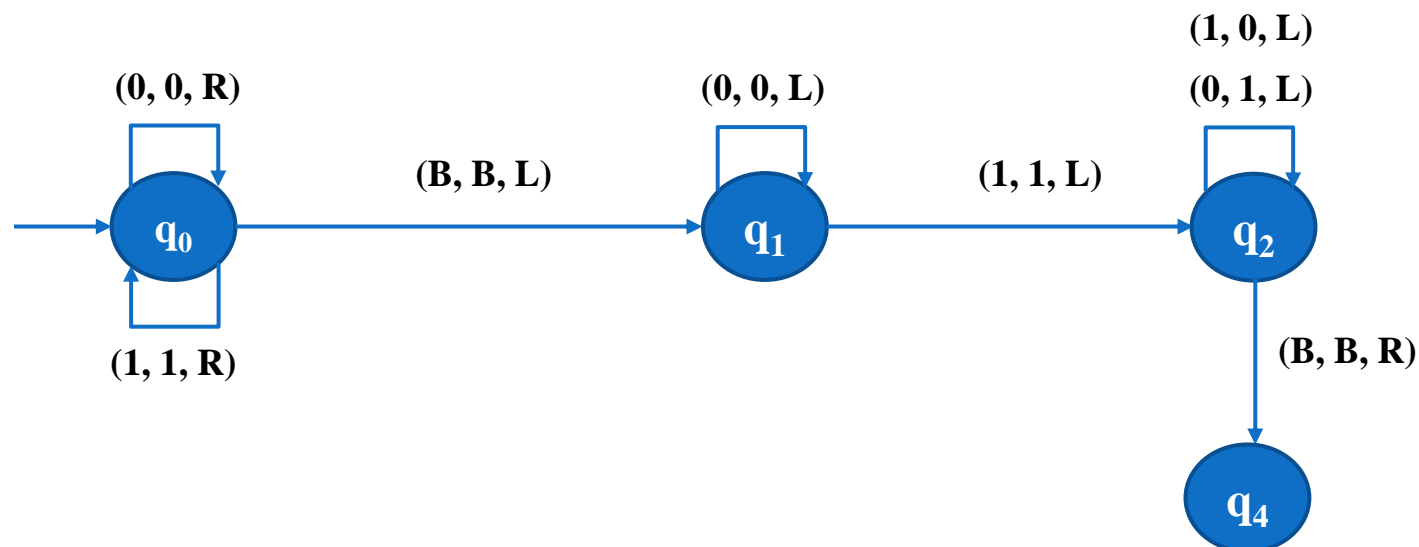
## EXERCISE

1. Construct turing machine to find 1's complement of binary number.
2. Construct turing machine to find 2's complement of binary number.
3. Construct turing machine as a comparator i.e. to compare the string as,  $a=b$  ,  $a>b$  ,  $a<b$
4. Construct turing machine to copy the string.

Construct turing machine to find 1's complement of binary number.

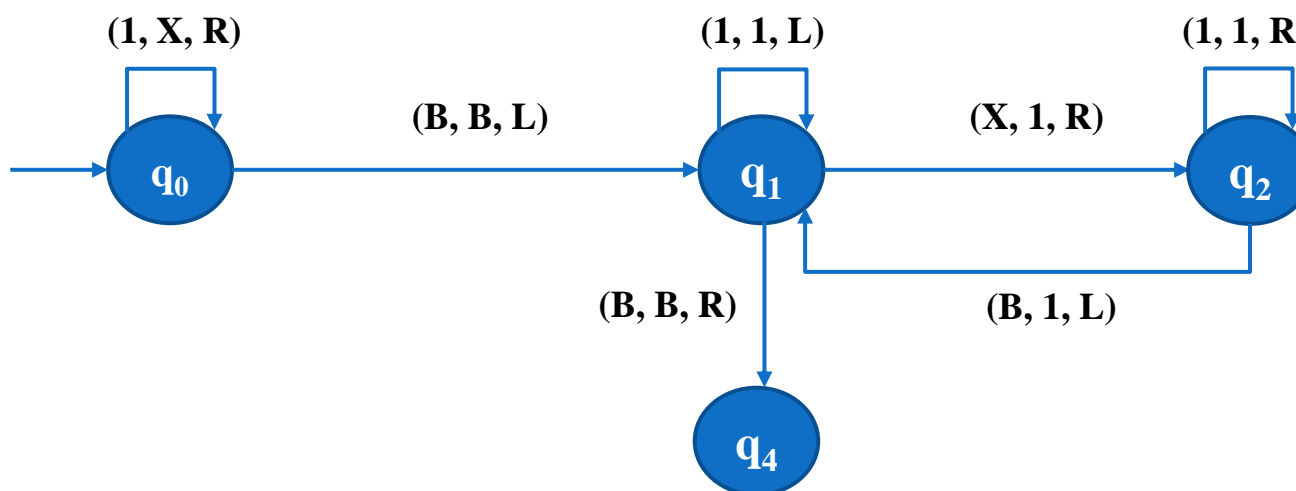


Construct turing machine to find 2's complement of binary number.



# Turing Machine as Copier

String: 111



# Thank You