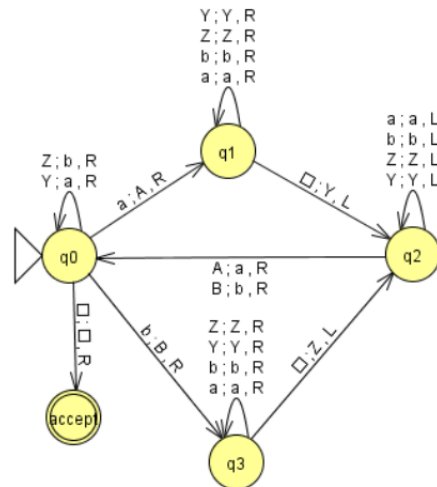


3

Create a Turing machine to duplicate the input string on the tape. Assume an alphabet of $\{a, b\}$.



3.8b

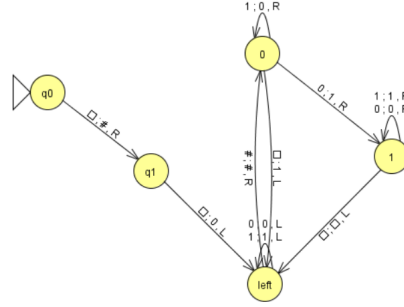
An implementation-level description of the Turing Machine $M_1 = \{w | w \text{ contains twice as many 1s as 0s}\}$ is as follows:

M_1 = "On input string w :

1. Mark the start of the tape (by marking with unique symbol and shifting every cell of the tape right one cell).
2. Scan the tape and mark the first 0 that has been unmarked. If no unmarked 0 is found, go to stage 5. Otherwise, move the head back to the front of the tape.
3. Scan the tape and mark the first 1 that has not been marked. If no unmarked 1 is found, reject. Otherwise, move the head to the front of the tape.
4. Again, scan the tape and mark the first 1 that has not been marked. If no unmarked 1 is found, reject. Otherwise, go to step 2.
5. Move the head back to the front of the tape. Scan the tape to see if any unmarked 1s remain. If none are found, *accept*. Otherwise *reject*."

4

Create a Turing machine that, starting on an empty string, counts in binary on the tape. (To make it easier, the binary is represented in reverse.)



5

An implementation level description of the Turing Machine $L = \{p\#t \mid p, t = \{0, 1\}^* \text{ and the string } p \text{ appears somewhere in the string } t\}$ is as follows:

$L =$ “On input string w :

1. Read and mark the first symbol. If blank, *reject*. If #, *accept*.
2. Read and mark the first unmarked symbol after #. If no # exists, or there are no symbols after the #, *reject*. If the symbol is different than the symbol marked in step 1, repeat step 2. If it is the same as the symbol marked in step 1, continue to step 3.
3. Move the head to the symbol marked in step 1. Read and mark the next unmarked symbol. Then read and mark the next unmarked symbol after the #. If these two symbols are different, move the head left to the symbol marked in step 1, unmarking all symbols marked in step 3, and repeat step 2. If these two symbols are the same, repeat step 3. If there are no unmarked symbols after the #, *reject*. If there are no unmarked symbols before the #, *accept*.”

I affirm that I have upheld the highest principles of honesty and integrity in my academic work and have not witnessed a violation of the honor code.