

1.

- 1) 1945
- 2) Enigma
- 3) Turing Test
- 4) The Chemical Basis of Morphogenesis
- 5) The Imitation Game

2.

a)

Assumptions:

- \$ is the left end marker symbol
- # is the blank symbol
- The input string given in the first tape is in the form of "\$#w#" where w is the string.
- $q_0$  is the initial state

Turing machine TM described with tuple  $(K, \Sigma, \delta, s, H)$

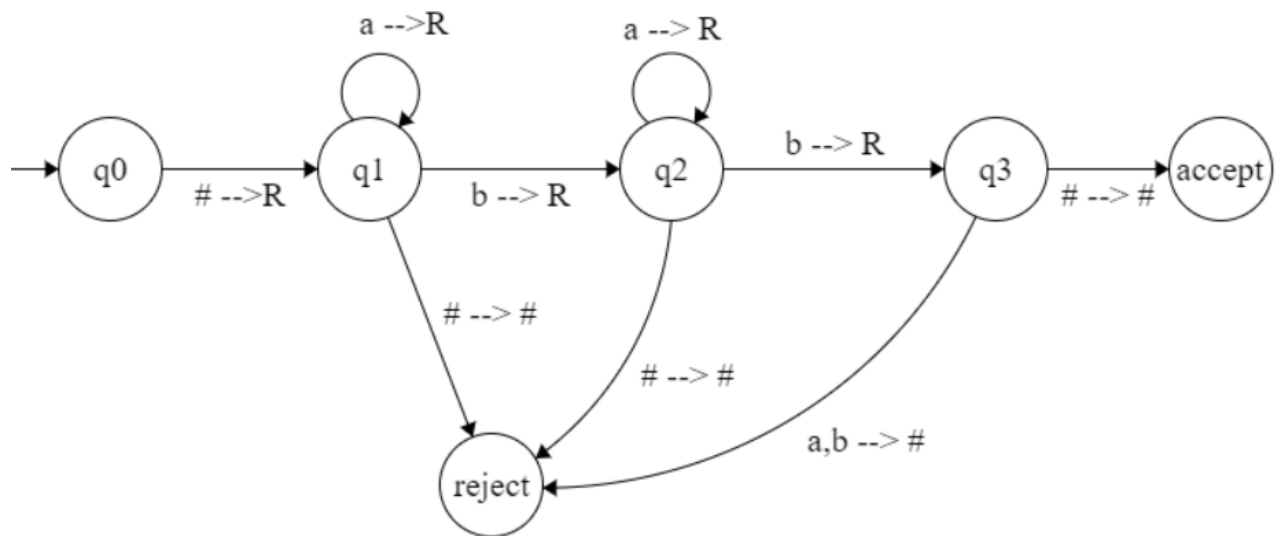
$K(\text{states}) = \{q_0, q_1, q_2, q_3, \text{accept}, \text{reject}\}$

$\Sigma(\text{alphabet}) = \{\#, \$, a, b\}$

$s(\text{initial state}) = q_0$

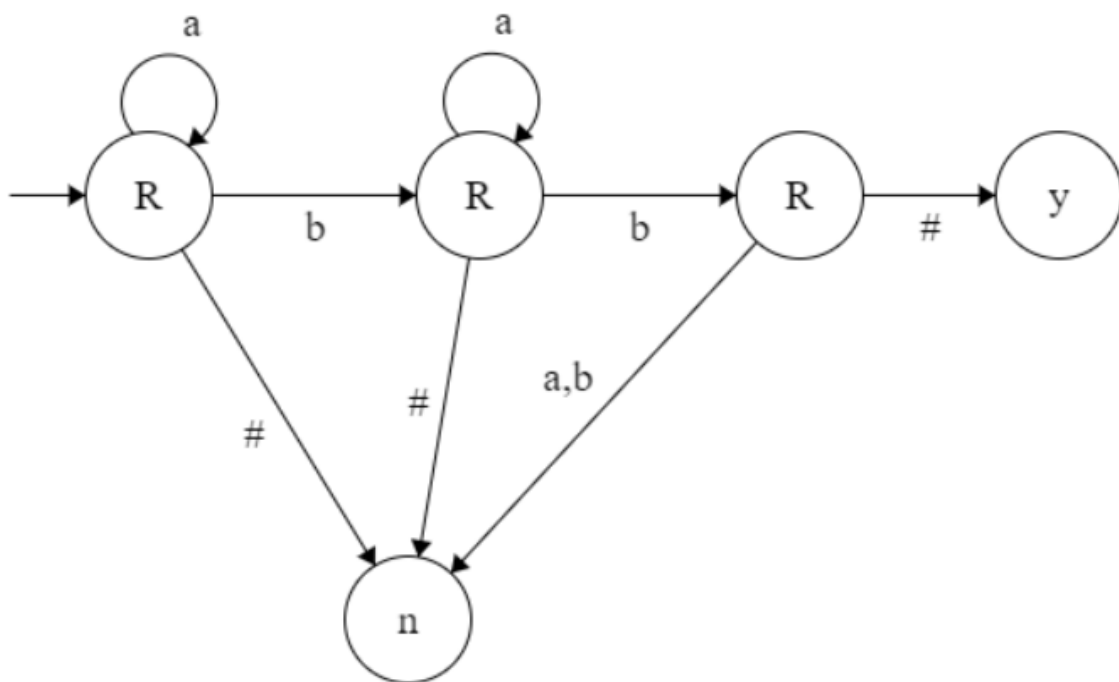
$H(\text{halting states}) = \{\text{accept}, \text{reject}\}$

$q$	$\sigma$	$\delta(q, \sigma)$
$q_0$	#	$(q_1, R)$
$q_1$	a	$(q_1, R)$
$q_1$	b	$(q_2, R)$
$q_1$	#	$(\text{reject}, \#)$
$q_2$	a	$(q_2, R)$
$q_2$	b	$(q_3, R)$
$q_2$	#	$(\text{reject}, \#)$
$q_3$	#	$(\text{accept}, \#)$
$q_3$	a, b	$(\text{reject}, \#)$



b) Assumptions:

- $\$$  is the left end marker symbol
- $\#$  is the blank symbol
- The input string given in the first tape is in the form of " $\$w\#$ " where  $w$  is the string.



3.

Assumptions:

- \$ is the left end marker symbol
- # is the blank symbol
- The input string given in the first tape is in the form of "\$#w#" where w is the "a,b" where a and b in binary form
- The given Turing Machines do operate on a whole number on tape(s).
- Subtract Machine subtracts 1 on a given tape. For example it converts 110 to 101 when applied.
- Multiply Machine takes two inputs on separate tapes and subtracts them and writes the result into a second tape. For example, it converts "010, 011" to "010, 110" (it writes the result into second tape)
- Addition Machine's behavior is similar to Multiply Machine.

Algorithm:

- 1) Read the first tape. When encountered ",", write the rest of the characters into the second tape and convert them into blank character, and make the third tape input as "\$#0#". After this step; the first tape only contains a, the second tape only contains b and the third tape only contains zero as binary.
- 2) Use the addition machine with the first input as first tape, and second input as third tape.  $a+0$  results in a and the result a is written on the third tape.
- 3) Use a subtract machine to reduce the second tape by one.
- 4) Loop:
  - a) Use subtract machine on the second tape (reduce b by one) if it is greater than zero else halt
  - b) Use the multiply machine as first input the first tape, and use the third tape as second input. After completing this stage the values on the tapes will be: "a", "b-n", " $a^n$ " in order.
- 5) When the machine hits zero on the second tape, it halts and the result is on the third tape which is  $a^b$ .