

Consider the language $B = \{w\#w \mid w \in \{0,1\}^*\}$. The Turing machine M_1 that decides the language B.

In the state diagram, reject state has not shown for simplicity. If the state does not have an outgoing transition for any symbol, then it moves to the reject state q_{reject} .

In the state diagram, the label $0 \rightarrow x, R$ appears on the transition from q_1 to q_2 . This label signifies that, the state q_1 with head reading 0, the machine goes to state q_2 , writes x, and moves the head to the right.

a.

Consider the input string 11. The sequence of configurations that M_1 enters are as follows:

```
→ q111
→ xq31
→ x1q3␣ [∵ q3 is not reading␣, so it enters to reject state]
→ x1␣qreject
```

Finally, M_1 enters the q_{reject} state. Hence input 11 is rejected.

b.

Consider the input string 1#1. The sequence of configurations that M_1 enters are as follows:

```
→ q11#1
→ xq3#1
→ x#q51
→ xq6#x
→ q7x#x
→ xq1#x
→ x#q8x
→ x#xq8␣
→ x#x␣qaccept
```

Finally, M_1 enters q_{accept} state. Thus, the input 1#1 is accepted.

c.

Consider the input string 1##1. The sequence of configurations that M_1 enters are as follows:

```
→ q11##1
→ xq3##1
→ x#q5#1 [∵ q5 is not reading #, so it enters to reject state]
→ x##qreject1
```

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Finally, M_1 enters q_{reject} state. Thus, the input 1##1 is rejected.

d.

Consider the input string 10#11. The sequence of configurations that M_1 enters are as follows:

$\rightarrow q_1 10\#11$
 $\rightarrow xq_3 0\#11$
 $\rightarrow x0q_3 \#11$
 $\rightarrow x0\#q_5 11$
 $\rightarrow x0q_6 \#x1$
 $\rightarrow xq_7 0\#x1$
 $\rightarrow q_7 x0\#x1$
 $\rightarrow xq_1 0\#x1$
 $\rightarrow xxq_2 \#x1$
 $\rightarrow xx\#q_4 x1$
 $\rightarrow xx\#xq_4 1$ [$\because q_4$ is not reading 1, so it enters to reject state]
 $\rightarrow xx\#x1q_{\text{reject}}$

Finally, M_1 enters q_{reject} state. Thus, the input 10#11 is rejected.

e.

Consider the input string 10#10. The sequence of configurations that M_1 enters are as follows:

$$\begin{aligned}
&\rightarrow q_1 10 \# 10 \\
&\rightarrow x q_3 0 \# 10 \\
&\rightarrow x 0 q_3 \# 10 \\
&\rightarrow x 0 \# q_5 10 \\
&\rightarrow x 0 q_6 \# x 0 \\
&\rightarrow x q_7 0 \# x 0 \\
&\rightarrow q_7 x 0 \# x 0 \\
&\rightarrow x q_1 0 \# x 0 \\
&\rightarrow x x q_2 \# x 0 \\
&\rightarrow x x \# q_4 x 0 \\
&\rightarrow x x \# x q_4 0 \\
&\rightarrow x x \# q_6 x x \\
&\rightarrow x x q_6 \# x x \\
&\rightarrow x q_7 x \# x x \\
&\rightarrow x x q_1 \# x x \\
&\rightarrow x x \# q_8 x x \\
&\rightarrow x x \# x q_8 x \\
&\rightarrow x x \# x x q_8 \sqcup \\
&\rightarrow x x \# x x \sqcup q_{\text{accept}}
\end{aligned}$$

Finally, M_1 enters q_{accept} state. Thus, the input $10 \# 10$ is accepted.