



## Gradiance Online Accelerated Learning

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based on Chapter 8 of HMU.

### Help

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1. A nondeterministic Turing machine  $M$  with start state  $q_0$  and accepting state  $q_f$  has the following transition function:

$\delta(q,a)$	0	1	B
$q_0$	$\{(q_1, 0, R)\}$	$\{(q_1, 0, R)\}$	$\{(q_1, 0, R)\}$
$q_1$	$\{(q_1, 1, R), (q_2, 0, L)\}$	$\{(q_1, 1, R), (q_2, 1, L)\}$	$\{(q_1, 1, R), (q_2, B, L)\}$
$q_2$	$\{(q_f, 0, R)\}$	$\{(q_2, 1, L)\}$	$\{\}$
$q_f$	$\{\}$	$\{\}$	$\{\}$

Deduce what  $M$  does on any input of 0's and 1's. Demonstrate your understanding by identifying, from the list below, the ID that CANNOT be reached on some number of moves from the initial ID  $q_010100101$ .

- a)  $0q_f11111111$
- b)  $0q_f1110101$
- c)  $q_f011111111$
- d)  $0111q_20101$

Answer submitted: **b)**

Your answer is incorrect.

Hint: notice that  $M$  can travel right as far as it likes in state  $q_1$ , changing all symbols to 1's. It may then guess to go to state  $q_2$ . What happens in state  $q_2$ ? The notation for Turing machines and their moves is in Section 8.2.2 (p. 326), and the formal notion of moves between instantaneous descriptions is in Section 8.2.3 (p. 327).

#### Question Explanation:

$M$  starts by replacing the first symbol by 0 and then enters state  $q_1$ , moving right. In state  $q_1$ , it moves right, changing all symbols, including blanks, to 1. However, at any time, it may also "guess" that it is time to enter  $q_2$ . In that branch, the symbol being scanned is left unchanged, and  $M$  moves left, over 1's, until it meets the initial 0. At that point, it moves right and enters state  $q_f$ .

The correct choice is: **c)**

2. A Turing machine  $M$  with start state  $q_0$  and accepting state  $q_f$  has the following transition function:

$\delta(q,a)$	0	1	B
$q_0$	$(q_0, 1, R)$	$(q_1, 1, R)$	$(q_f, B, R)$
$q_1$	$(q_2, 0, L)$	$(q_2, 1, L)$	$(q_2, B, L)$
$q_2$	-	$(q_0, 0, R)$	-
$q_f$	-	-	-

Deduce what  $M$  does on any input of 0's and 1's. Hint: consider what happens when  $M$  is started in state  $q_0$  at the left end of a sequence of any number of 0's (including zero of them) and a 1. Demonstrate your understanding by identifying the true transition of  $M$  from the list below.

- $q_0 1010 \vdash^* 1001 B q_f$
- $q_0 1010 \vdash^* 0101 B q_f$
- $q_0 0011 \vdash^* 1101 B q_f$
- $q_0 1010 \vdash^* 0101 q_f$

Answer submitted: **b)**

You have answered the question correctly.

Question Explanation:

$M$  inverts all 0's and 1's on its input and then accepts. To see why, notice that for any string  $w$ ,  $M$  makes the following sequence of transitions:

$(q_0, 0 \dots 01w) \vdash^* 1 \dots 1 q_0 1w \vdash^* 1 \dots 11 q_1 w \vdash^* 1 \dots 1 q_2 1w \vdash^* 1 \dots 10 q_0 w$

Also, started in state  $q_0$  with only 0's to its right,  $M$  moves to the right, replacing the 0's by 1's, and accepts when it reaches a blank.

3. The Turing machine  $M$  has:

- States  $q$  and  $p$ ;  $q$  is the start state.
- Tape symbols 0, 1, and B; 0 and 1 are input symbols, and B is the blank.
- The following next-move function:

State	Tape	Move
	Symbol	
$q$	0	$(q, 0, R)$
$q$	1	$(p, 0, R)$
$q$	B	$(q, B, R)$
$p$	0	$(q, 0, L)$
$p$	1	none (halt)
$p$	B	$(q, 0, L)$

Your problem is to describe the property of an input string that makes  $M$  halt. Identify a string that makes  $M$  halt from the list below.

- 0100
- 00100

- c) 1001  
d) 11010

Answer submitted: **c)**

Your answer is incorrect.

Hint: notice that the only way for M to halt is to enter state p and then see a 1 on the tape. How can that happen? In the case of this input, M does not halt; it enters the sequence of ID's: q1001 |- 0p001 |- q0001 |- 0q001 |- 00q01 |- 000q1 |- 0000pB |- 000q0 |- 0000qB |- 0000BqB |- ...

The informal notion of the behavior of a Turing machine is in Section 8.2.2 (p. 326). The formal notion of moves of a TM as a sequence of instantaneous descriptions is in Section 8.2.3 (p. 327).

#### Question Explanation:

In state q, as long as M sees only 0's, it leaves its tape unchanged and continues moving right. The only way M can halt is by being in state p and seeing a 1. The only way that M gets to state p is by being in state q and seeing a 1. Since in state q, M moves right when it sees the 1, we conclude that M will halt if it ever finds two consecutive 1's.

We need to make sure that there are no other ways M could halt, say by seeing a single 1. However, if M enters state p, it will surely have 0 to its left, because it changes the 1 to a 0. If in state p, M sees 0 or B, it moves left, back to the 0 and enters state q again. At that point, M will proceed right, in state q, until it sees another 1.

The correct choice is: **d)**

#### 4. The Turing machine M has:

- States q and p; q is the start state.
- Tape symbols 0, 1, and B; 0 and 1 are input symbols, and B is the blank.
- The following next-move function:

State	Tape	Move
	Symbol	
q	0	(q,0,R)
q	1	(p,0,R)
q	B	(q,B,R)
p	0	(q,0,L)
p	1	none (halt)
p	B	(q,0,L)

Simulate M on the input 1010110, and identify one of the ID's (instantaneous descriptions) of M from the list below.

- a) 000000p0  
b) 000001q0  
c) 0000q110  
d) 00000q10

Answer submitted: **b)**

Your answer is incorrect.

A possible error is that you did not notice that when, in state  $q$ ,  $M$  sees a 1, it replaces the 1 by 0. The formal notion of moves of a TM as a sequence of instantaneous descriptions is in Section 8.2.3 (p. 327).

Question Explanation:

Here is the complete sequence of ID's after which  $M$  halts:  $q1010110 \mid - 0p010110 \mid - q0010110 \mid - 0q010110 \mid - 00q10110 \mid - 000p0110 \mid - 00q00110 \mid - 000q0110 \mid - 0000q110 \mid - 00000p10$

The correct choice is: **c)**

5. A nondeterministic Turing machine  $M$  with start state  $q_0$  and accepting state  $q_f$  has the following transition function:

$\delta(q,a)$	0	1	B
$q_0$	$\{(q_1,0,R)\}$	$\{(q_1,0,R)\}$	$\{(q_1,0,R)\}$
$q_1$	$\{(q_1,1,R), (q_2,0,L)\}$	$\{(q_1,1,R), (q_2,1,L)\}$	$\{(q_1,1,R), (q_2,B,L)\}$
$q_2$	$\{(q_f,0,R)\}$	$\{(q_2,1,L)\}$	$\{\}$
$q_f$	$\{\}$	$\{\}$	$\{\}$

Simulate all sequences of 5 moves, starting from initial ID  $q_01010$ . Find, in the list below, one of the ID's reachable from the initial ID in EXACTLY 5 moves.

- a)  $01111q_1$
- b)  $0q_f111$
- c)  $0111q_1$
- d)  $0q_2110$

Answer submitted: **d)**

You have answered the question correctly.

Question Explanation:

Here are all the possible sequences of ID's with up to 5 moves.

$q_01010 \mid - 0q_1010 \mid - 01q_110 \mid - 011q_10 \mid - 0111q_1 \mid - 01111q_1$   
 $q_01010 \mid - 0q_1010 \mid - 01q_110 \mid - 011q_10 \mid - 0111q_1 \mid - 011q_21$   
 $q_01010 \mid - 0q_1010 \mid - 01q_110 \mid - 011q_10 \mid - 01q_210 \mid - 0q_2110$   
 $q_01010 \mid - 0q_1010 \mid - 01q_110 \mid - 0q_2110 \mid - q_20110 \mid - 0q_f110$   
 $q_01010 \mid - 0q_1010 \mid - q_20010 \mid - 0q_f010$