


q_3	1	1	0	0
q_2	1	0	0	1

	q_3	q_2	q_1	q_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

- ① $CZ(3,2):$ $12, 13, 14, 15$ 为真
- ② $CCNOT(3,0,2):$ $12, 9, 14, 11$
 $9 \leftrightarrow 13; 11 \leftrightarrow 15$
- ③ $CCCNOT(3,1,0,2):$ $12, 9, 14, 15$
 $11: 1011 \leftrightarrow 15$
- ④ $CCCE(3,2,1,0):$ $12, 9, 14$
 $15 \rightarrow -15$
- ⑤ $CCCN(3,2,1,0):$ $12, 9, 15$
 $14 \leftrightarrow 15$
- ⑥ $CCCE(3,2,1,0):$ $12, 9$
 $15 \rightarrow -15$

q_0 _____

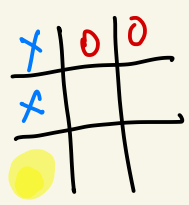
q_1 _____

q_2 _____

q_3 _____

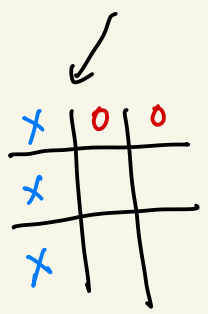
Bonus :

init:

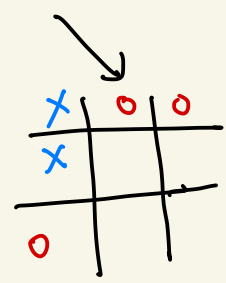


Totally $5 \times 4 \times 3 \times 2 \times 1$

1 \wedge 24 ~~4~~ cases



new case, a winning case
win directly

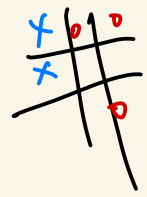
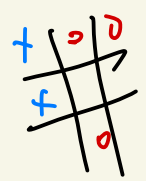
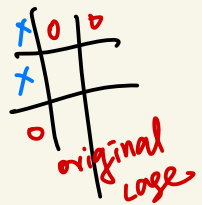
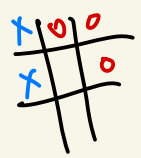
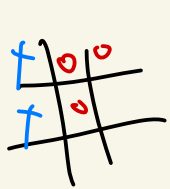


original cases

24 case

4 case =

4 case \



case 1

X	0	0
X	0	

To win, with two rounds

X	0	0
X	0	
X		

only this case is possible

X	0	0
X	0	0 ₂
X ₁	X ₃	0 ₄

X	0	0
0	0	0 ₂
X ₁	0 ₄	X ₃

X	0	0
X	0	X ₃
X ₁	0 ₂	0 ₄

X	0	0
X	0	0 ₄
X ₁	0 ₂	X ₃

X	0	0
X	0	X ₃
X ₁	0 ₄	0 ₂

X	0	0
X	0	0 ₄
X ₁	X ₃	0 ₂

X	0	0
X	0	X ₁
X ₃	0 ₂	X ₃

X	0	0
X	0	X ₁
X ₃	0 ₂	X ₃

X	0	0
X	0	X ₁
X ₃	0 ₂	

X	0	0
0	0	X ₁
0 ₂	X ₃	

X	0	0
X	0	X ₁
X ₃	0 ₂	

X	0	0
X	0	X ₁
X ₃	0 ₂	

X	0	0
X	0	0 ₂
X ₃	X ₁	

X	0	0
X	0	0 ₂
X ₁	X ₃	

X	0	0
X	0	X ₃
X ₁	0 ₂	X ₁

X	0	0
X	0	X ₁
X ₃	0 ₂	X ₃

X	0	0
X	0	X ₃
X ₁	0 ₂	

X	0	0
0	0	
X ₁	0 ₂	

X	0	0
X	0	0 ₂
X ₃	X ₁	

X	0	0
X	0	0 ₂
X ₃	X ₁	

X	0	0
X	0	X ₃
X ₁	0 ₂	X ₁

X	0	0
X	0	
X ₁	0 ₂	X ₃

X	0	0
X	0	
0 ₂	X ₁	

X	0	0
X	0	
0 ₂	X ₁	

case 2

X	0	0
X	0	0

, can win by

10/24

X		
X		
X		

4/24

X		
X		
X		

X	0	0
X	0	0
X ₁	X ₃	

X	0	0
X	0	0
X ₁	X ₃	

X	0	0
X	0	0
X ₁	0 ₂	

X	0	0
X	0	0
X ₁	0 ₂	X ₃

X	0	0
X	X ₃	0
X ₁	0 ₂	

X	0	0
X	0	0
X ₁	X ₃	0 ₂

X	0	0
X	X ₁	0
X ₃	0 ₂	

X	0	0
X	X ₁	0
0 ₂	X ₃	

X	0	0
X	X ₁	0
X ₃	0 ₂	

X	0	0
X	X ₁	0
0 ₂	X ₃	

X	0	0
X	X ₁	0
X ₃	0 ₂	

X	0	0
X	X ₁	0
X ₃	0 ₂	

X	0	0
X	0 ₂	0
X ₃	X ₁	

X	0	0
X	0	0
X ₁	X ₃	0 ₂

X	0	0
X	X ₃	0
0 ₂	X ₁	

X	0	0
X	X ₃	0
0 ₂	X ₁	

X	0	0
X	X ₃	0
X ₁	0 ₂	

X	0	0
X	X ₃	0
X ₁	0 ₂	

X	0	0
0	0	0
X ₃	X ₁	

X	0	0
X	0	0
X ₃	X ₁	

X	0	0
X	X ₃	0
0 ₂	X ₁	

X	0	0
X	0	0
0 ₂	X ₃	X ₁

X	0	0
X	X ₃	0
0 ₂	X ₁	

X	0	0
X	X ₃	0
X ₁	0 ₂	

case 3

win by

4

4

original case

X	0	0
X		
0		

X	0	0
X	X	
0		X

X	0	0
X	X	X
0		

case 4

win by

6+4=10/24

4/24

4/24

X	0	0
X		
		0

X	0	0
X		
X		0

X	0	0
X	X	X
0		

X	0	0
X	X	
		X

X	0	0
X	0	X3
X1	0	

X	0	0
X	0	
X1	0	X3

X	0	0
X	X3	0
X1	0	

X	0	0
X		0
X1	0	X3

X	0	0
X	X3	
X1	0	0

X	0	0
X		X3
X1	0	0

X	0	0
X	X1	0
X3	0	

X	0	0
X	X1	0
0		X3

X	0	0
X	X1	X3
0	0	

X	0	0
X	X1	
0	0	X3

X	0	0
X	X1	X3
0	0	

X	0	0
X	X1	
X3	0	0

X	0	0
X	0	X1
X3	0	

X	0	0
X	0	X1
0	X3	

X	0	0
X	X3	X1
0	0	

X	0	0
X		X1
0	0	X3

X	0	0
X	X3	X1
0	0	

X	0	0
X		X1
X3	0	0

X	0	0
X	0	X3
0	X1	

X	0	0
X	0	
X3	0	X1

X	0	0
X	X3	0
0	X1	

X	0	0
X	0	0
X3	0	X1

X	0	0
X	0	
0	0	X1

X	0	0
X		X3
0	0	X1

case 5

win by

6+4=10/24

4/24

X	0	0
X		
		0

X	0	0
X		
X		0

X	0	0
X	X	X
		0

X	0	0
X	0	X3
X1	0	

X	0	0
X	0	
X1	X3	0

X	0	0
X	X3	0
X1	0	

X	0	0
X		0
X1	X3	0

X	0	0
X	X3	
X	0	0

X	0	0
X	X3	
X1	0	0

X	0	0
X	X1	0
X3	0	

X	0	0
X	X1	0
X3	0	

X	0	0
X	X1	X3
0	0	

X	0	0
X	X1	
0	0	X3

X	0	0
X	X1	X3
0	0	

X	0	0
X	X1	
X3	0	0

X	0	0
X	0	X3
X	0	

X	0	0
X	0	
X3	X1	0

X	0	0
X	X3	0
X1	0	

X	0	0
X		0
X3	X1	0

X	0	0
X	X3	
0	X1	0

X	0	0
X		X3
0	X1	0

X	0	0
X	0	X1
X3		0

X	0	0
X	0	X1
X3	0	

X	0	0
X	X3	X1
0		0

X	0	0
X		X1
0	X3	0

X	0	0
X	X3	X1
0	0	0

X	0	0
X		X1
X3	0	0

Output:

		.	.
.	.	.	.

* case 1:

00	110	IF	4
00	101	F	3
01	100	F	3

* case 2

00	110	F	3
00	101	IF	4
10	100	F	3
1000		IF	4

* case 3

1000		4
11000		4

* case 4

01	100	F	3
00	101	F	3
10	100	IF	4
1000		IF	4
11000		IF	4

* case 5

01	100	IF
00	110	F
10	100	F
11000		IF

00	11	0	$4+3+3=10$
00	10	1	$3+4+3=10$
0	110	0	$3+3+4=10$
10	100		$3+4+3=10$
10	00	1	$4+4+4=12$
11	000		$4+4+4=12$

(64)

X	0	0
X	X	0
0	0	X

	X	X
0	0	0

Highest probability

$\begin{bmatrix} 0000 \\ 11000 \end{bmatrix}$

4 4 4 4 4
 0 0 0 0 0
 1 0 0 0 0
 2 0 0 0 1
 3 0 0 0 1
 4 0 0 1 0
 5 0 0 1 0
 6 0 0 1 0
 7 0 0 1 1
 8 0 1 0 0
 9 0 1 0 0
 10 0 1 0 1
 11 0 1 0 1
 12 0 1 0 1
 13 0 1 1 0
 14 0 1 1 0
 15 0 1 1 1
 16 1 0 0 0
 17 1 0 0 0
 18 1 0 0 1
 19 1 0 0 1
 20 1 0 1 0
 21 1 0 1 0
 22 1 0 1 1
 23 1 0 1 1
 24 1 1 0 0
 25 1 1 0 0
 26 1 1 0 1
 27 1 1 0 1
 28 1 1 1 0
 29 1 1 1 0
 30 1 1 1 1
 31 1 1 1 1

① $CZ(4,3) : 24, 17, 26, 27, 28, 21, 30, 23$ reflect

② $CCX(4,0,1) : 24, 17, 26, 19, 28, 21, 30, 23$ reflect

$17 \leftrightarrow 25$
 $19 \leftrightarrow 27$
 $21 \leftrightarrow 29$
 $23 \leftrightarrow 31$

3 3 3 3 4 4

③ $CCCCX(4,3,2,1,0) : 24, 17, 26, 19, 28, 21, 23$ (R)

$30 \leftrightarrow 31$
 $CCCZ(4,3,2,1,0)$
 $31 \rightarrow -31$

④ $CCCCX(4,2,1,0,3) : 24, 17, 26, 19, 28, 21$ (B)

$23 \leftrightarrow 31$
 $CCCCZ(4,3,2,1,0)$
 $31 \rightarrow -31$

⑤ $CCX(4,3,1,2) : 24, 17, 30, 19, 28, 21$

26 $\underline{11} \underline{0} \underline{1} \underline{0} \leftrightarrow \underline{11} \underline{1} \underline{0} \underline{30}$

27 $\underline{11} \underline{0} \underline{1} \underline{1} \leftrightarrow \underline{11} \underline{1} \underline{1} \underline{31}$, no impact

⑥ $CCCCX(4,3,2,1,0) : 24, 17, 19, 28, 21$

$30 \leftrightarrow 31$
 $CCCCZ(4,3,2,1,0)$
 $31 \rightarrow -31$

⑦ $CCX(4,1,0,3) : 24, 17, 27, 28, 21$

19 $\underline{10} \underline{0} \underline{11} \leftrightarrow \underline{11} \underline{01} \underline{27}$

23 $\underline{10} \underline{11} \leftrightarrow \underline{11} \underline{11} \underline{31}$, no impact

⑧ $CCCCX(4,3,1,0,2) : 24, 17, 28, 21$

$27 \leftrightarrow 31$
 $CCCCZ(4,3,2,1,0)$
 $31 \rightarrow -31$

⑨ $CCX(4,3,2,0) : 24, 17, 29, 21$

28 $\underline{11100} \leftrightarrow \underline{11101} \underline{29}$

30 $\underline{11110} \leftrightarrow \underline{11111} \underline{31}$

⑩ $CCCCX(4,3,2,0,1) : 29 \leftrightarrow 31$ 3: 24, 17, 21

$CCCCZ(4,3,2,1,0)$ $31 \rightarrow -31$

⑪ $CCX(4,2,0,1) : 24, 17, 23$

21 $\underline{10101} \leftrightarrow \underline{10111} \underline{23}$

29 $\underline{11101} \leftrightarrow \underline{11111} \underline{31}$

⑫ $CCCCX(4,2,1,0,3) : 23 \leftrightarrow 31$: 24, 17

$CCCCZ(4,3,2,1,0)$ $31 \rightarrow -31$

