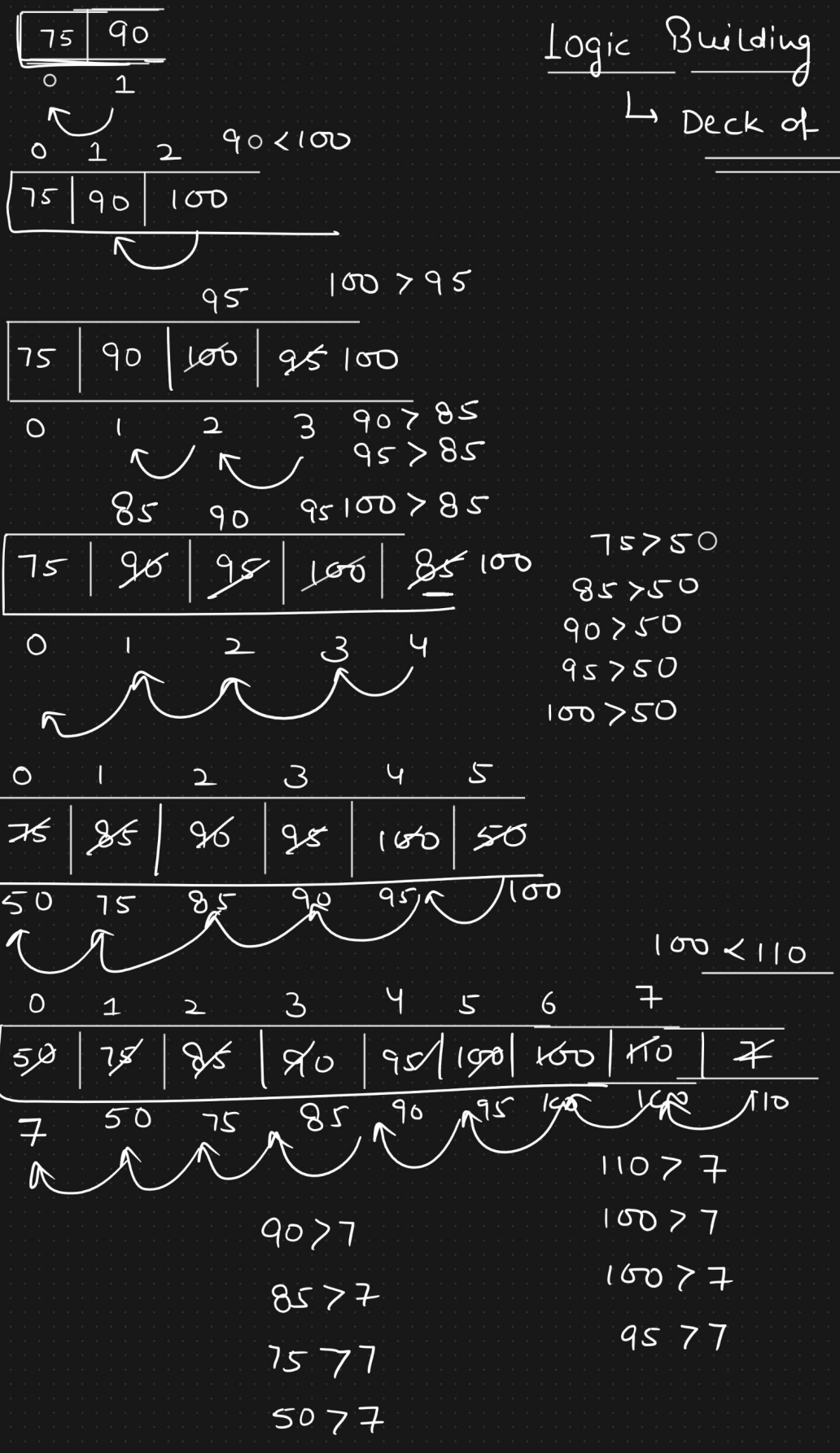
Insertion Sort

75, 90, 100, 95, 85, 50, 100, 110, 7

0 1 2 3 4 5 6 7 8

Logic Building

↳ Deck of cards



7, 50, 75, 85, 90, 95, 100, 100, 110

0 1 2 3 4 5 6 7 8

↳ Sorted array

Best case

Ascending order
- $n-1$ comparisons
- 0 swaps

10, 20, 30, 40, 50
0 1 2 3 4

$n = 5$

[10] — No comparison

[10 | 20] $10 < 20$ ①

[10 | 20 | 30] $20 < 30$ ②

[10 | 20 | 30 | 40] $30 < 40$ ③

[10 | 20 | 30 | 40 | 50] $40 < 50$ ④

n — $(n-1)$ comparisons $= O(n)$
- 0 swaps

$$T(n) = O(n)$$

Worst case

↳ Decending order

$n = 5$

50, 40, 30, 20, 10

0 1 2 3 4

n elements

C	S
1	1
2	2
3	3
4	4
1	1
n-1	n-1

50

0

50 > 40

~~50~~ 40 | ~~40~~ 50

0 1

50 > 30

40 > 30

~~40~~ | ~~50~~ | ~~30~~

30 40 50

50 > 20

40 > 20

30 > 20

20 30 40 50

~~30~~ | ~~40~~ | ~~50~~ | ~~20~~

50 > 10

10 20 30 40 50

~~20~~ | ~~30~~ | ~~40~~ | ~~50~~ | ~~10~~

40 > 10

30 > 10

20 > 10

comparisons → $1+2+3+---+n-1$

$$\Rightarrow \frac{(n-1)\,n}{2} = O(n^2)$$

Swaps

↳ $1+2+3+\ldots+n-1$

$$\frac{(n-1)n}{2} = O(n^2)$$

$$\boxed{T(n) = O(n^2)}$$

Best case → Ascending order
(Almost sorted → ascending order)

INSERTION SORT ⟹

$\Downarrow$

$O(n)$

Worst case → Descending order

$\Downarrow$

$O(n^2)$