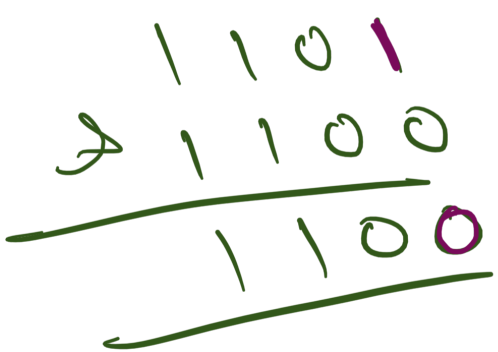
Bit Manipulation - II

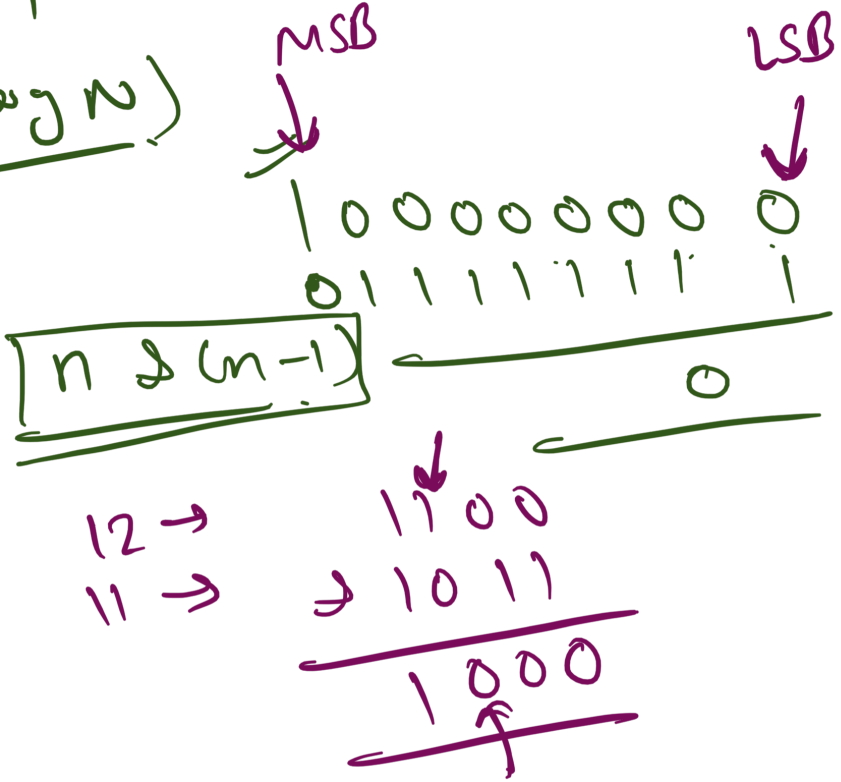
$\log N$

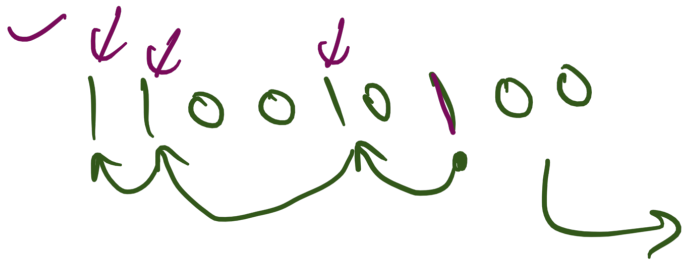
$n \& (n-1)$

Least significant set bit turns 0



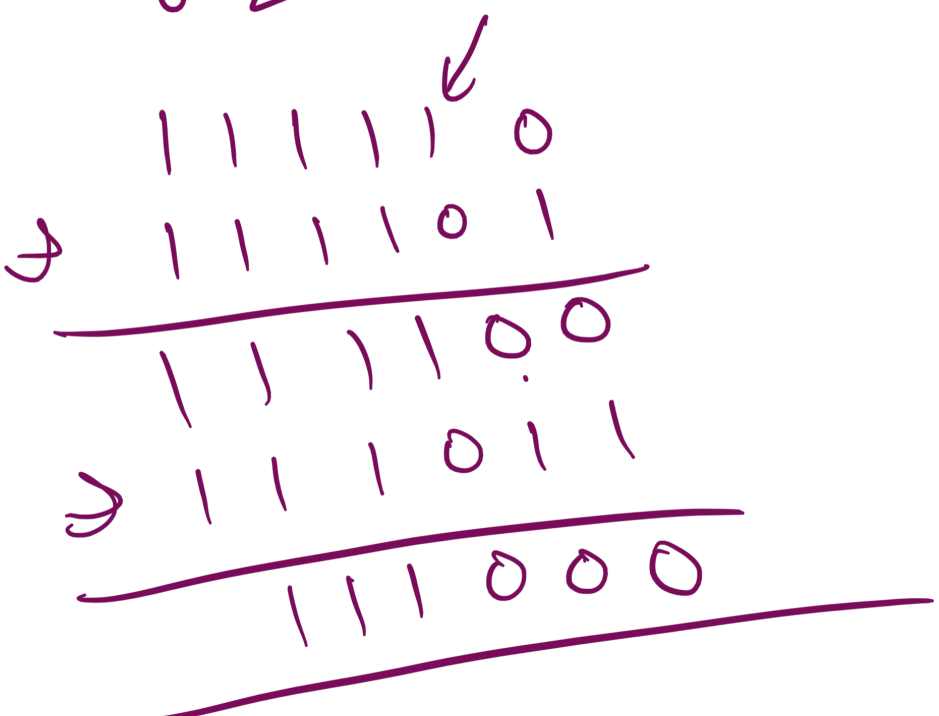
13 → 12





62

61



Find the only non-repeating element in an array where every other element repeats twice.

Using O(N²) a[] = {2, 1, 4, 1, 2, 3, 4} → O(N²)

Using HashSet → O(N)

Space → O(N)

XOR property

① $a \wedge a = 0$

$5 \wedge 5 = 0$

```
  101
^ 101
-----
  000  → 0
```

```
  101
^ 000
-----
  101  → 5
```

② $a \wedge 0 = a$

$a[] = \{2, 1, 4, 1, 2, 3, 4\}$

$res = \boxed{0 \wedge 2} = 2 \wedge 1 \wedge 4 \wedge 2$

$= x \wedge 4 \wedge 3 \wedge x$

$= y \wedge 3 \wedge y$

$= 3$

```
  001
^ 100
-----
  101  → 5
```

```
  10
^ 01
----
  11
^ 100
-----
  111
^ 010
-----
  101
```

Find the two non-repeating elements in an array where every other element repeats twice.

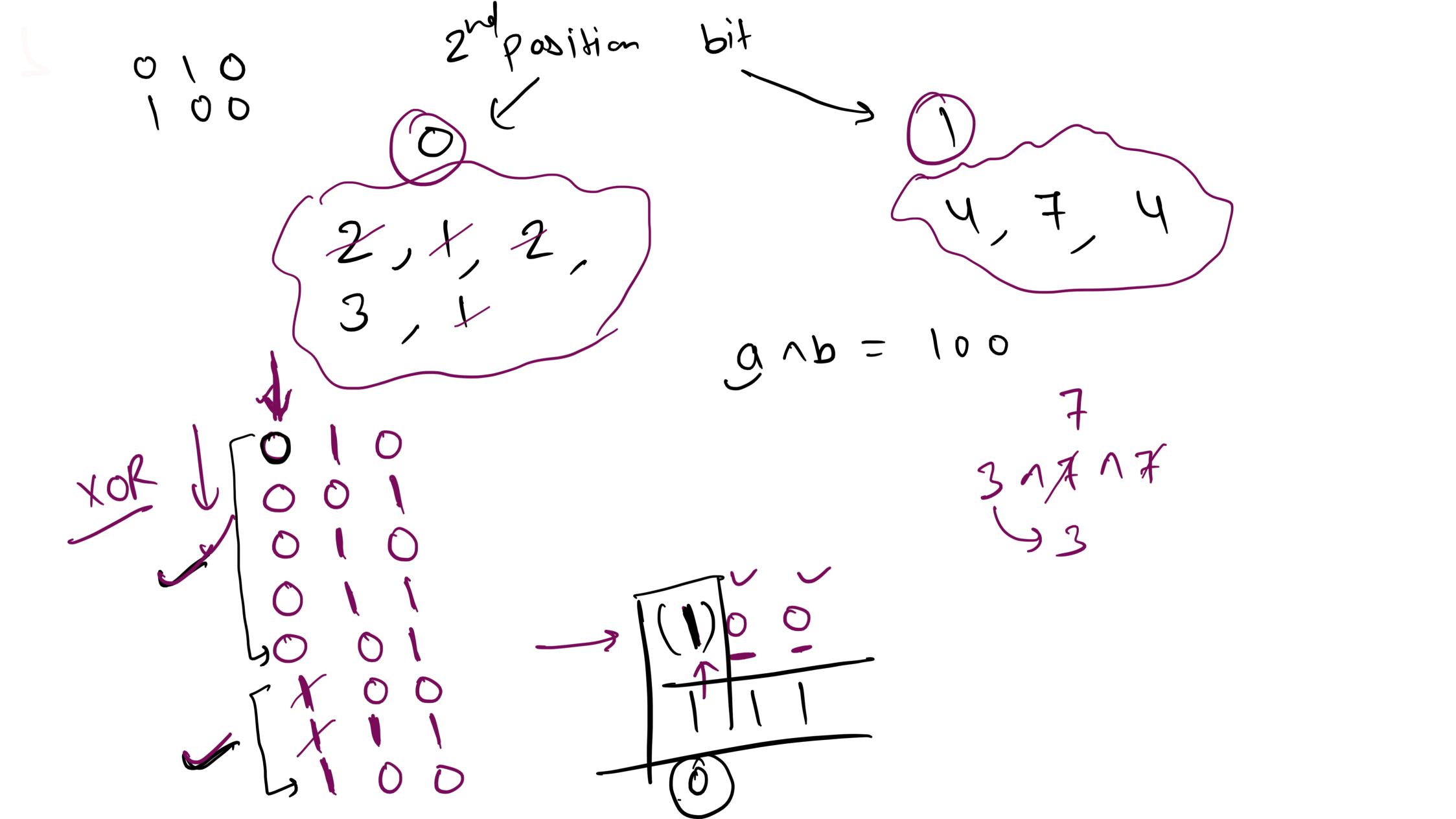
int a[] = {2, 4, 1, 2, 3, 7, 4, 1}

res = 0 ^ 2 ^ 4 ^ 1 ^ 2 ^ 3 ^ 7 ^ 4 ^ 1

res = 3 ^ 7 = 4

0 1 1
^ 1 1 1
1 0 0
2 1 0

Least significat set bit


0 1 0
1 0 0
2nd position bit
0
2, 1, 2,
3, 1
1
4, 7, 4
a ^ b = 1 0 0
7
3 ^ 7 ^ 7
3
XOR
0 1 0
0 0 1
0 1 0
0 1 1
0 0 1
0 0 0
0 1 1
1 0 0
(1) 0 0
0

int a[] = {2, 4, 1, 2, 3, 7, 4, 1}

$2^{nd} \rightarrow 0$

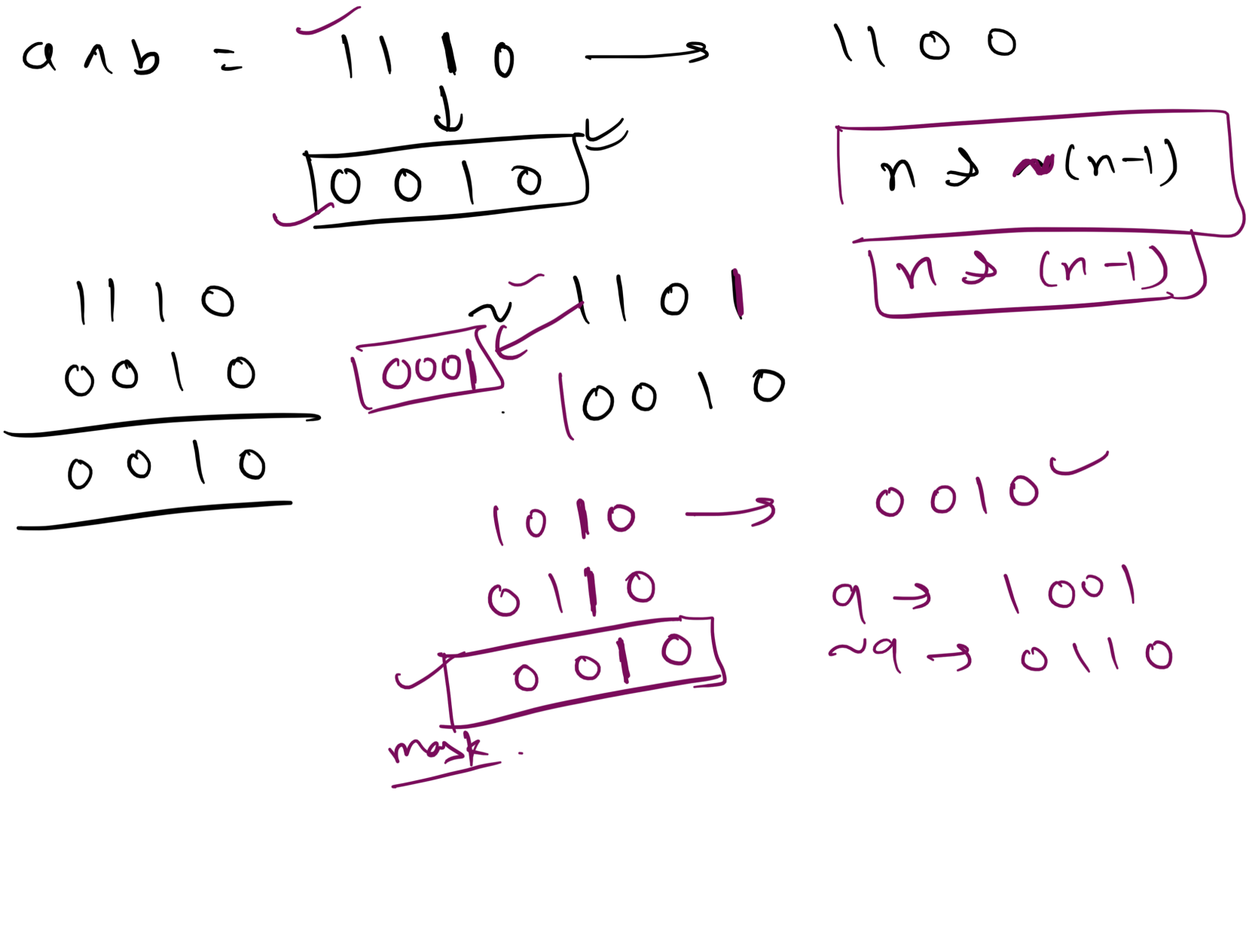
	1	0	0
2	0	1	0
1	0	0	1
2	0	1	0
3	0	1	1
∧ 1	0	0	1
	1	1	1 → (7)

	1	0	0
∧	1	1	1
	0	1	1 → (3)

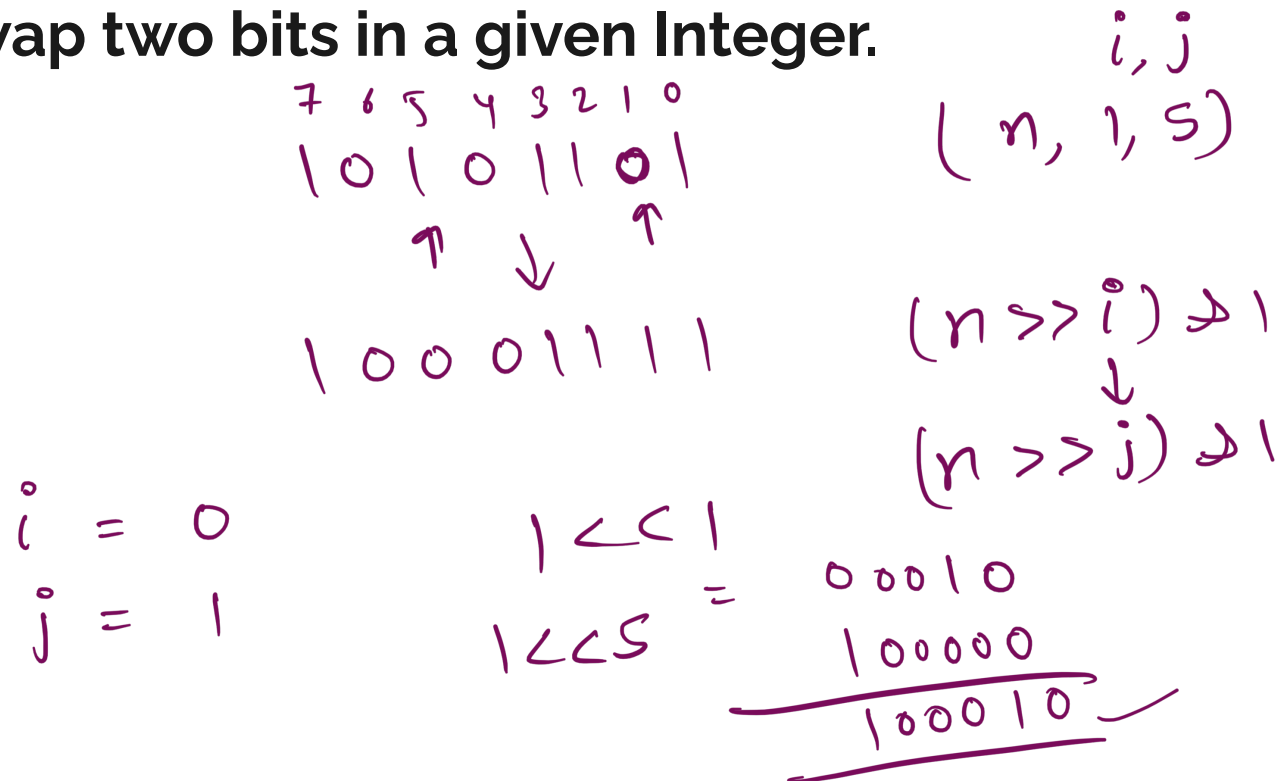
$3 \wedge 7 \wedge 7 \rightarrow 3$

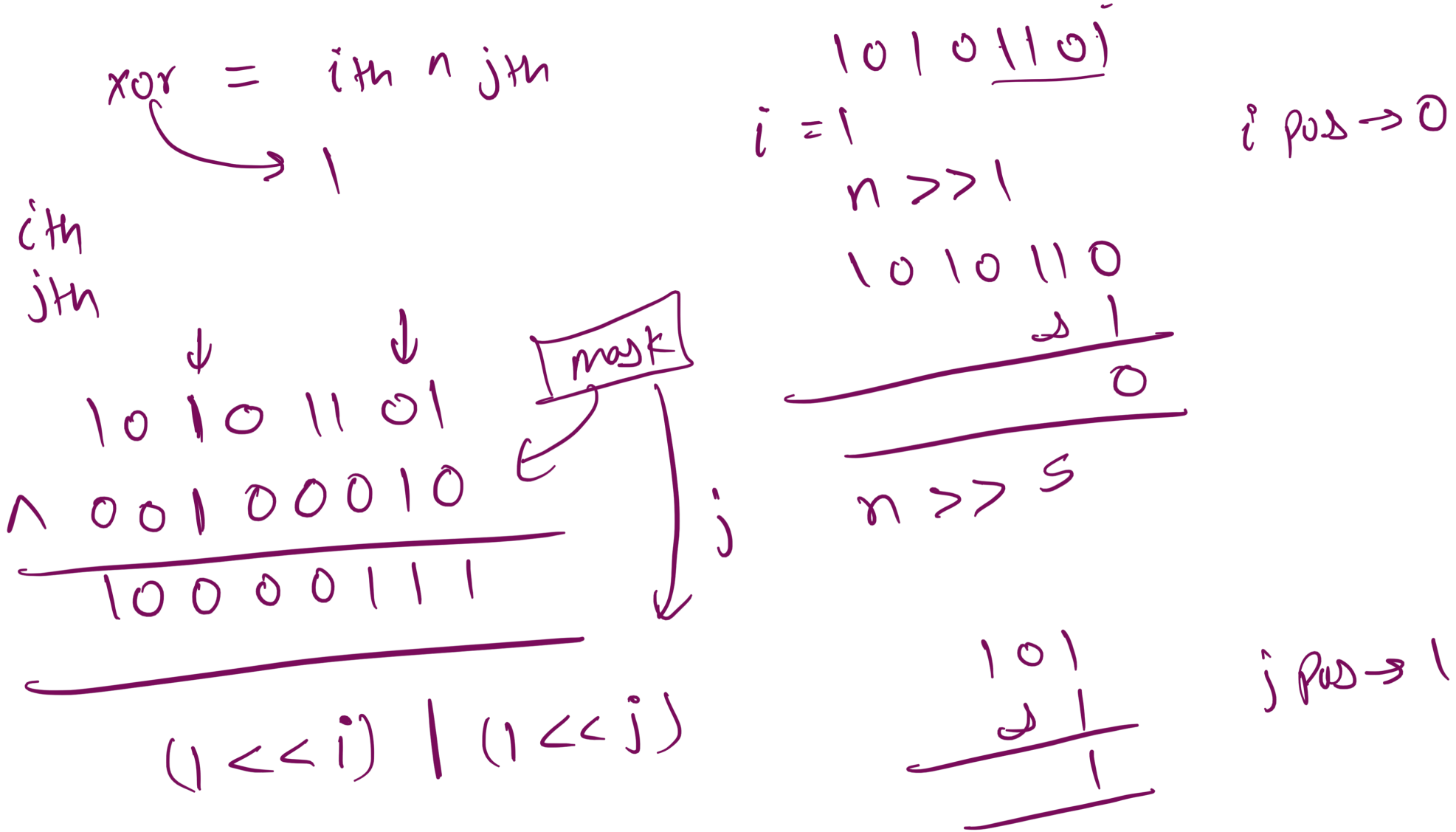
mask = 100 → 010 → 0

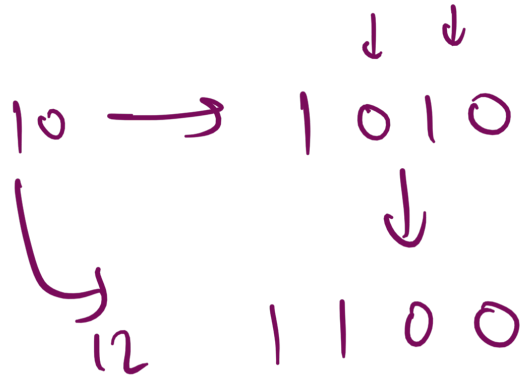
100	100
&010	&100
0	100


a ^ b = ~1110 → 1100
0010
n & ~(n-1)
n & (n-1)
1110
0010
0010
~1101
0001
10010
1010 → 0010~
0110
0010
mask
9 → 1001
~9 → 0110

Swap two bits in a given Integer.



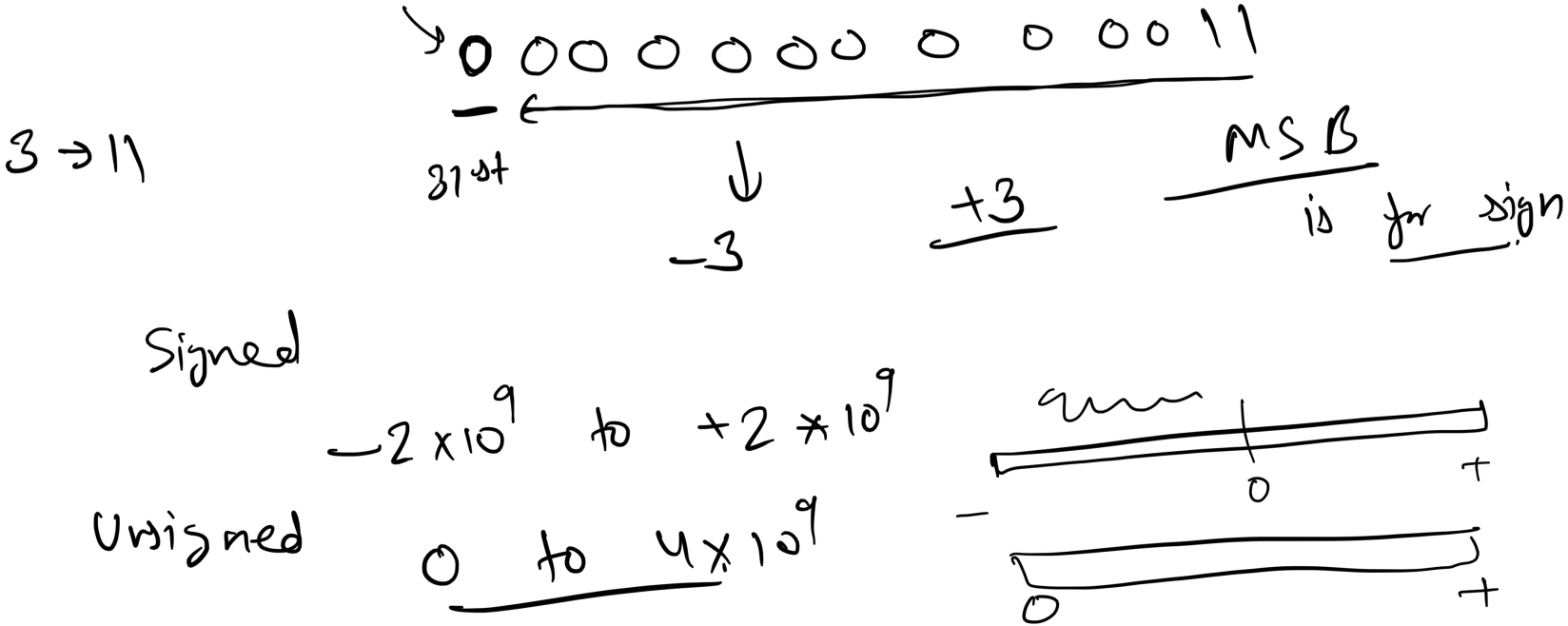

xor = ith n jth
1
ith
jth
10 10 11 01
& 00 1 00 0 10
10 0 0 0 1 1 1
mask
i
j
(1 << i) | (1 << j)
10 10 11 0 1
i = 1
n >> 1
10 10 11 0
& 1
0
n >> 5
i pos → 0
10 1
& 1
1
j pos → 1

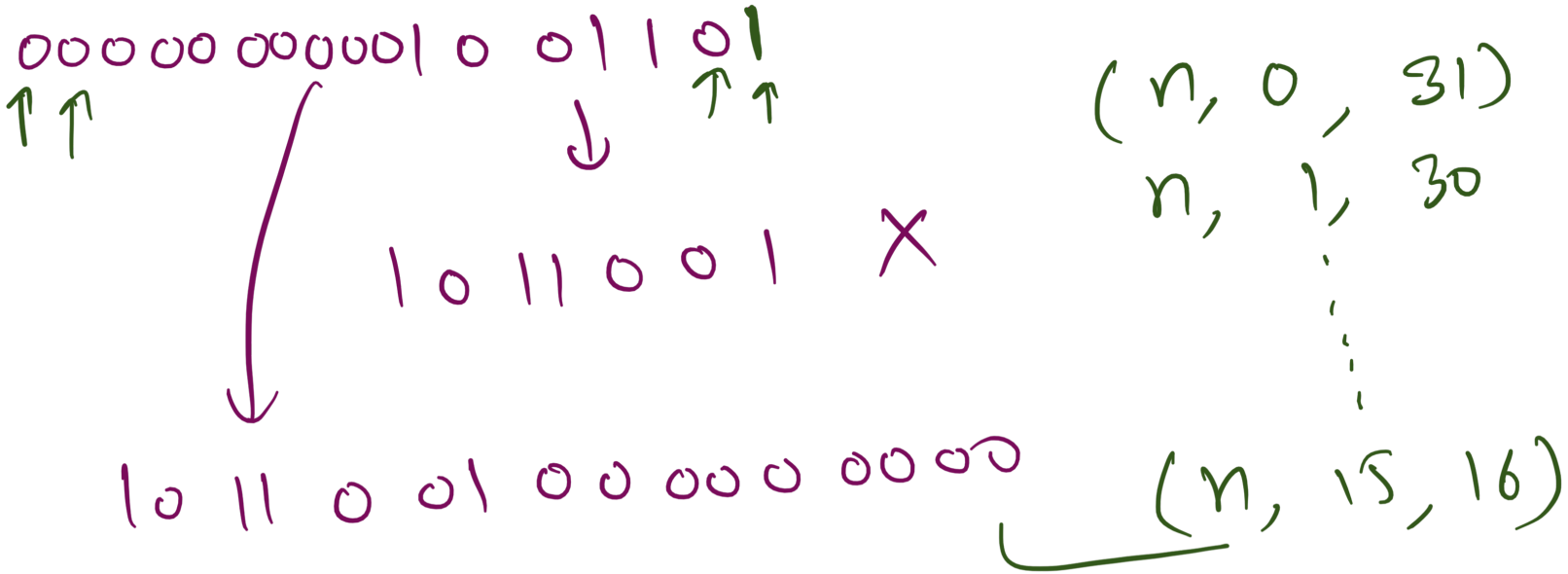


a, b

$$\begin{cases} a = a \wedge b \\ b = a \wedge b \\ a = a \wedge b \end{cases}$$

Reverse the bits of an 32 bit unsigned integer.





① swap two bits

for (0 ... 15)

swap(n, i, 31-i)

② Res = 0

1 00 1 0 1

3 → 11

reverse

-ve

11 0 00 00 00 0

30 zeroes

$2^{30} + 2^{31}$ =

1 << 31

+

0 << 30

+

1 << 29

+

0 << 28

+

0 << 27

+

1 << 26

+

⋮

1 0 0 0 0 0 ⟷ 1

31 zeros

2^{31} →

−

Practice Problems

1. Find the only non-repeating element in an array where every other element repeats thrice.
2. https://www.interviewbit.com/courses/programming/bit-manipulation/