Today's Agenda

- Binary to decimal
- Decimal to Binary
- Addition of Binary numbers
- Bitwise Operators
- Properties
- Single Number
- Left Shift
- Right Shift.

Today's Quote

It's not the will to win that matters, everyone has that.
It's the will to prepare to win that matters.

Decimal Number System :-

↓

{0, 1, 2, 3, 4, 5, 6, 7, 8, 9} Base → 10.

342 → 300 + 40 + 2 = $3\times10^2 + 4\times10^1 + 2\times10^0$

2563 → 2000 + 500 + 60 + 3 → $2\times10^3 + 5\times10^2 + 6\times10^1 + 3\times10^0$

Binary Number System :- {0,1} Base → 2

$1\ 1\ 0 \rightarrow 1\times2^2 + 1\times2^1 + 0\times2^0 \rightarrow 4 + 2 + 0 \rightarrow 6$

$1\ 0\ 1\ 1 \rightarrow 1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 = 11$

0	10	20
1	11	21
2	12	22
3	13	23
⋮	⋮	⋮
9	19	29

0 → 0 1 0 → 2 100 → 4 110 → 6

1 → 1 1 1 → 3 101 → 5 111 → 7

Binary to decimal

4	3	2	1	0
1	0	1	1	0

$0\times2^0 = 0$

$1\times2^1 = 2$

$1\times2^2 = 4$

$0\times2^3 = 0$

$1\times2^4 = 16$

22

$(10110)_2 = (22)_{10}$

6	5	4	3	2	1	0
1	0	1	1	0	1	0
↓	↓	↓	↓	↓	↓	↓
2^6	2^5	2^4	2^3	2^2	2^1	2^0

$\rightarrow 2^6 + 2^4 + 2^3 + 2^1$

$\rightarrow 64 + 16 + 8 + 2 \Rightarrow 90$

$(1011010)_2 \rightarrow (90)_{10}$

$(1\ 0\ 2\ 0\ 1\ 0)_2$ (5 4 3 2 1 0) → Invalid.

Decimal to Binary

2	20	
2	10	0
2	5	0
2	2	1
2	1	0
	0	1

4 3 2 1 0
→ 1 0 1 0 0
2^4 2^2

⇒ 16 + 4 ⇒ 20

$(10100)_2 \rightarrow (20)_{10}$

2	45	
2	22	1
2	11	0
2	5	1
2	2	1
2	1	0
	0	1

5 4 3 2 1 0
(1 0 1 1 0 1)
2^5 2^3 2^2 2^0

$2^5 + 2^3 + 2^2 + 2^0$
→ 32 + 8 + 4 + 1
→ 45.

$(45)_{10} \rightarrow (101101)_2$

Addition

```
  (1) (1)
   3  6  8
+  4  5  3
-------------
   8  2  1
```

0 + 0 = 0
0 + 1 = 1
1 + 0 = 1
1 + 1 = $(10)_2 \rightarrow (2)_{10}$

```
  1  1
5 → 1 0 1
3 → 0 1 1
-----------
1 0 0 0 → 8
```

```
  1  1
  1 0 1 → 5
  1 1 1 → 7
-----------
1 1 0 0 → 12
```

$(3)_{10} \longrightarrow (11)_2$

```
    1  1
  1 0 1 1 0 → 22
+ 0 0 1 1 1 → 7
-------------
1 1 1 0 1 → 29
```

Bitwise Operators

And, Or, XOR, Not, Left shift, Right shift
& | ^ !/~ << >>

0 → 1
1 → 0

A	B	A & B	A | B	A ^ B
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

→ same same
(Puppy shame)

XOR → Addition without carry.

1 + 1 = ⓘ0

Bitwise operators on numbers.

5 & 6

5 → 1 0 1
6 → 1 1 0
4 → 1 0 0

5 & 6 = 4

20 | 45

20 → 0 1 0 1 0 0
45 → 1 0 1 1 0 1
1 1 1 1 0 1 → 61

(20 | 45) → 61

20 ^ 45 = 57 .

20 → 0 1 0 1 0 0
45 → 1 0 1 1 0 1
---
1 1 1 0 0 1 → 57
---

41 & 21 → 41 → 1 0 1 0 0 1
21 → 0 1 0 1 0 1
---
0 0 0 0 0 1 → 1

Properties :-

A & 1 = ?

A = 10
1 0 1 0
& 0 0 0 1

A & 1 0 0 0 0

A = 9
1 0 0 1
& 0 0 0 1
---
0 0 0 1

A & 1 → 0 . if last bit is 0 => A is even
→ 1 . if last bit is 1 => A is odd .

0 → unset
1 → set .

5 4 3 2 1 0
1 0 1 1 0 1
Even | odd = odd

5 4 3 2 1 0
1 0 1 1 0 0
Even | Even = Even

2) $A \& 0 = 0$

$$\begin{array}{r} A\ 1\ 0\ 1\ 1 \\ \&\ A\ 1\ 0\ 1\ 1 \\ \hline 1\ 0\ 1\ 1 \end{array}$$

3) $A \& A = A$

4) $A \mid 0 = A$

5) $A \mid A = A$

6) $A \wedge 0 = A$

$$\begin{array}{l} A \rightarrow 1\ 0\ 1 \\ 0 \rightarrow 0\ 0\ 0 \\ \hline 1\ 0\ 1 \end{array}$$

7) $A \wedge A = 0$

$$\begin{array}{l} A \rightarrow 1\ 0\ 1 \\ A \rightarrow 1\ 0\ 1 \\ \hline 0\ 0\ 0 \end{array}$$

10:00pm – 10:12pm.

8) Commutative property.

$a \& b = b \& a$

$a \mid b = b \mid a$

$a \wedge b = b \wedge a$

$\underbrace{a \& b}_{z} \& c = c \& \underbrace{a \& b}_{x}$

9) Associative property.

$(a \& b) \& c = a \& (b \& c)$

$(a \mid b) \mid b = a \mid (b \mid c)$

$(a \wedge b) \wedge c = a \wedge (b \wedge c)$

$\rightarrow a \wedge b \wedge a \wedge d \wedge b \rightarrow a \wedge a \wedge b \wedge b \wedge d$

$\rightarrow 0 \wedge d$

$\rightarrow d$

$1 \wedge 3 \wedge 5 \wedge 3 \wedge 2 \wedge 1 \wedge 5 = 2$

$2 \nearrow 7 \nearrow 4 \nearrow 6 \nearrow 7 \nearrow 2$

Ques Given an integer array, where every element repeats twice except for one element which appears once, find that unique element.

A = [6, 9, 6, 10, 9] Ans = 10.

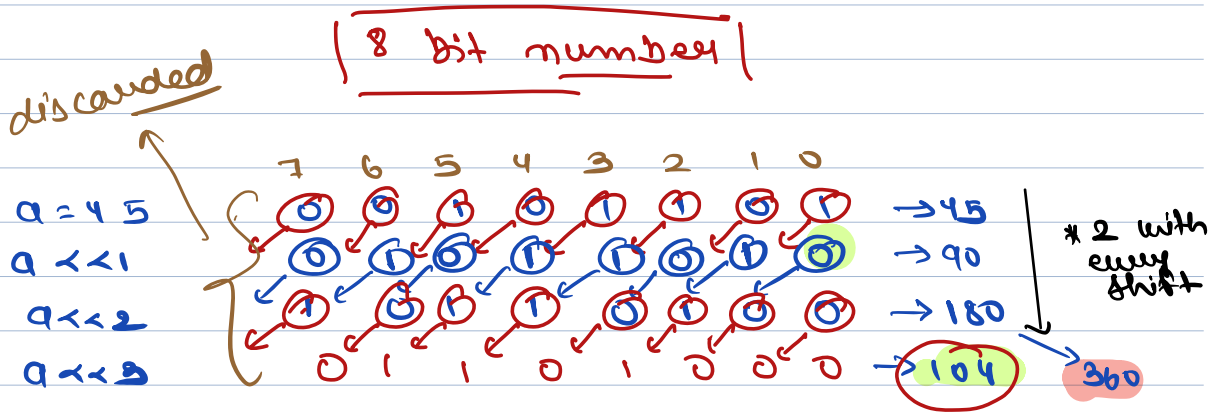
A = [2, 3, 5, 6, 3, 6, 2] Ans = 5

Ans → Run a loop & take XOR of all array elements.

```
ans = 0
for i → 0 to (N-1)
    ans ^= A[i]
return ans
```

T.C → O(N)
S.C → O(1).

Left Shift (<<) int → 4 Bytes → 32 bits.



Overflow. 360 is too large to store in 8 bits.

$a << 1 = a * 2 \rightarrow a * 2^1$

$a << 2 = a * 4 \rightarrow a * 2^2$

$a << 3 = a * 8 \rightarrow a * 2^3$

$a << n = a * 2^n$

$1 << n = 2^n$

True when no overflow.

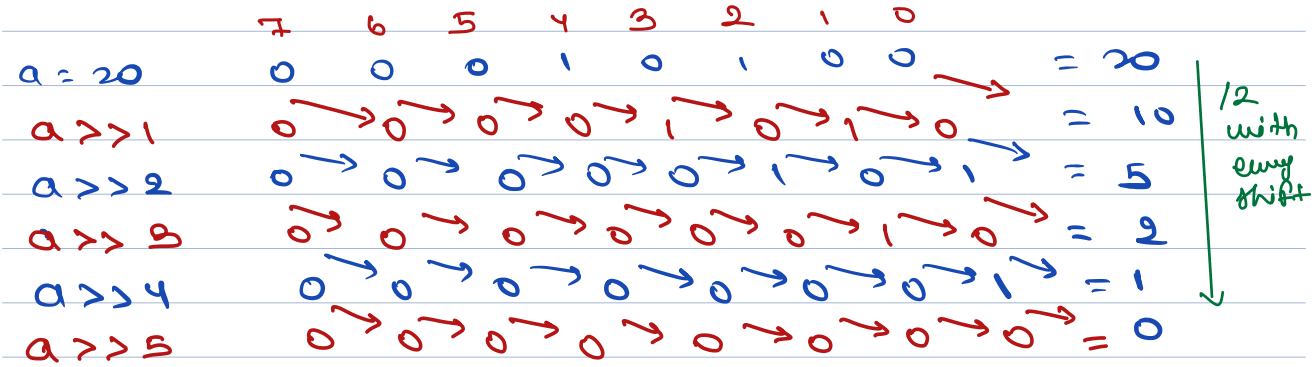
8 bit

7 6 5 4 3 2 1 0

1 1 1 1 1 1 1 1

$2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0 = 255$

Right shift (>>)



$a >> 1 \Rightarrow \frac{a}{2}$

$a >> 2 \Rightarrow \frac{a}{2^2}$

$a >> 3 \Rightarrow \frac{a}{2^3}$

$a >> n = a/2^n$

→

~~18~~, ~~20~~, ~~15~~, ~~30~~, ~~10~~, ~~14~~

player → 1

18

14

30

&

player → 2

20

15

10

1 2 3 4 5 6

18, 20, 15, 30, 10, 14

odd

18
+ 15
+ 10
43

even

20
+ 30
+ 14
64

player 1

14

player 2