1. **Decimal no. system**

base : 10 , digits : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

$3849 = 3\times10^{3} + 8\times10^{2} + 4\times10^{1} + 9\times10^{0}$

2. **Binary no. system**

base : 2, digits : 0, 1

$1101 = 1\times2^{3} + 1\times2^{2} + 0\times2^{1} + 1\times2^{0}$

$8 + 4 + 0 + 1 = 13$

$11001 = 1\times2^{4} + 1\times2^{3} + 0\times2^{2} + 0\times2^{1} + 1\times2^{0}$

$= 16 + 8 + 0 + 0 + 1 = 25$

binary to decimal

Decimal to binary

$(25)_{10} = (11001)_2$

2	25	
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

$(45)_{10} = (101101)_2$

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

$(101101)_2 = (45)_{10}$

$1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$32 + 0 + 8 + 4 + 0 + 1 = 45$

$(30)_{10} = (11110)_2$

2	30	
2	15	0
2	7	1
2	3	1
2	1	1
	0	1

$(11110)_2 = (30)_{10}$

$16 + 8 + 4 + 2 + 0 = 30$

Addition of binary numbers

```
  0 1 1 1
  3 8 4 9
+ 2 7 5
-------
  4 1 2 4
```

Sum.

d = sum % 10

c = sum / 10

```
  1  1  1  1
     1  0  1  1
+       1  1  1
-----------------
Sum  2  2  3  2
d=Sum%.2  1  0  0  1  0
c= sum/2
```

d = sum % 2

c = sum / 2

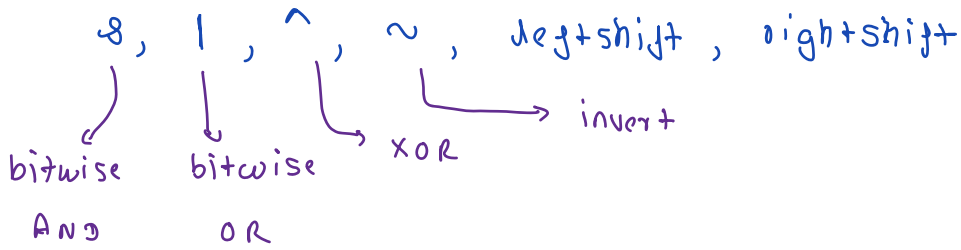
```
1 0 1 1   →  11
  1 1 1   →   7
---------     ---
1 0 0 1 0     18
```

eg-2

```
  1  1  1  1
     1  1  0  1
     0  1  1  1
-----------------
Sum  2  3  2  2
d = Sum%.2  1  0  1  0  0
c = Sum/2
```

```
1 1 0 1   →  13
  1 1 1   →   7
---------     ---
1 0 1 0 0     20
```

Bitwise operators



& → 0 is dominating

| → 1 is dominating

^ → same same puppy shame

a	b	a & b	a | b	a ^ b	~a
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0

1. `int A = 13;`
   `int B = 10;`
   `Sopln ( A & B);` 8

```
  1 1 0 1   → 13
& 1 0 1 0   → 10
-----------
  1 0 0 0     8
```

2. `int A = 13;`
   `int B = 10;`
   `Sopln ( A | B);` 15

```
  1 1 0 1   → 13
| 1 0 1 0   → 10
-----------
  1 1 1 1     15
```

3. `int A = 13;`
   `int B = 10;`
   `Sopln ( A ^ B);` 7

```
  1 1 0 1   → 13
^ 1 0 1 0   → 10
-----------
  0 1 1 1     7
```

Important facts

n is an int no.

$n \,\&\, 0 = 0$

$n \,\&\, n = n$

$n \mid 0 = n$

$n \mid n = n$

$n \wedge 0 = n$

$n \wedge n = 0$

Brainstorming exercise

$n \,\&\, 1 =$

n = 20

```
  1 0 1 0 0
& 0 0 0 0 1
-----------
  0 0 0 0 0
```

n = 10

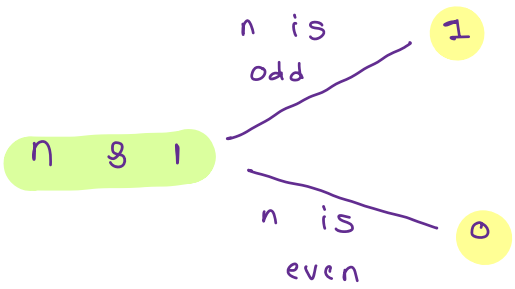
```
  1 0 1 0
& 0 0 0 1
---------
  0 0 0 0
```

n = 13

```
  1 1 0 1
& 0 0 0 1
---------
  0 0 0 1
```

n = 9

```
  1 0 0 1
& 0 0 0 1
---------
  0 0 0 1
```



n = 17

```
  1 0 0 0 1
& 0 0 0 0 1
-----------
  0 0 0 0 1
```

n = 18

```
  1 0 0 1 0
& 0 0 0 0 1
-----------
  0 0 0 0 0
```

Commutative

A, B, C → int no.

1. A & B = B & A
2. A | B = B | A
3. A ^ B = B ^ A

A & B & C = A & C & B = B & A & C = B & C & A = C & A & B = C & B & A

A | B | C = A | C | B = B | A | C = B | C | A = C | A | B = C | B | A

A ^ B ^ C = A ^ C ^ B = B ^ A ^ C = B ^ C ^ A = C ^ A ^ B = C ^ B ^ A

5 ^ 3 ^ 5 ^ 8 ^ 3 = 5 ^ 5 ^ 3 ^ 3 ^ 8

0 ^ 0 ^ 8

0 ^ 8 = 8

```
  1 0 1
^ 0 1 1
-------
  1 1 0
^ 1 0 1
-------
  0 0 1 1
^ 1 0 0 0
---------
  1 0 1 1
^ 0 0 1 1
---------
  1 0 0 0
```

Q.2 Single element

Given an array in which all no. are coming twice except for a single no. Find the single element.

A = [5 9 4 9 8 5 4]

TC: O(n)

SC: O(1)

```
int Solve (int [] A ) {
    int ans=0;
    for(int i=0; i< A.length; i++) {
        ans= ans ^ A[i];
    }
    return ans;
}
```

ans = 5^9^4^9^8^5^4

= 5^5^9^9^4^4^8

= 0 0 0 ^8

= 8

leftshift <<

with every left shift the no. is twiced.

a = 13	0 0 1 1 0 1	⇒	13
a<<1	0 1 1 0 1 0	⇒	26
a<<2	1 1 0 1 0 0	⇒	52

$a << 1 = 2a$

$a << 2 = 4a$

$a << 3 = 8a$

$a << N = (2^N)\, a$

$1 << N = 2^N$

↓

O(1)

Right shift >>

with every right shift no. is getting halved

a = 13	0 0 1 1 0 1	→ 13
a >> 1	0 0 1 1 0	→ 6
a >> 2	0 0 1 1	→ 3

a >> 1 = a / 2

a >> 2 = a / 4

a >> 3 = a / 8

⋮

a >> N = a / 2^n

Doubts
=

a = 25	11001	=	25
a << 1	110010	=	50
a << 2	1100100	=	100

a << 1 = 2a

a << 2 = 4a

a << 3 = 8a

⋮

a << N = (2^N) a

40 << 3 = 320

80 → 160 → 320

A = 3

temp = 1 to 9

1	2	3
8	9	4
7	6	5

i	j	n
0	0	3
1	1	1

CF

A = [9 5 -2 4 3 1 7]
0 1 2 3 4 5 6

B = 4

left	right
4	0
3	1
2	2
1	3
0	4

A = [9 5 -2 4 3 1 7]
0 1 2 3 4 5 6

i = B-1

j = n-1

sum = 9+5+-2+4

ans = ~~16~~ ~~19~~ 22

sum	i	j
9+5+-2+4-4+7	3	6
9+5+-2+7-(-2)+1	2	5
9+5+7+1-5+3	1	4
9+7+1+3-9+4	0	3
	-1	2

```
i >= 0 {
    sum -= A[i]
    sum += A[j]
    i--;
    j--;
}
```

Q. No. of minimum swaps to make all ele <= B togeth

A: [1 10 15 2 9 13 4]
0 1 2 3 4 5 6

B = 5
ans = 2

A: [25 30 2 18 7 6 9 50 33]
0 1 2 3 4 5 6 7 8

B = 10
ans = 1

A: [19 11 3 9 7 25 6 20 4]
0 1 2 3 4 5 6 7 8

B = 10
ans = 1

A: [19 11 3 9 7 25 6 20 4]
0 1 2 3 4 5 6 7 8

B = 10
K = 5

i	j	swaps ↳ val > B
0	4	2
1	5	2 - 1 + 1
2	6	2 - 1 → 1
3	7	1 + 1
4	8	2

```
if (A[s-1] > B) {
    swaps--;
}
if (A[e] > B) {
    swaps++
}
```