decimal → [0–9]

8 4 1 2 3

$8*10^4$ $4*10^3$ $1*10^2$ $2*10^1$ $3*10^0$

Binary number system [0, 1]

5 4 3 2 1 0

1 0 1 1 0 1

MSB

2^5 2^4 2^3 2^2 2^1 2^0

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

$= 45.$

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

$(45)_{10}$ → $(101101)_2$

Quiz 1

$(1\ 1\ 0\ 1\ 0\ 1)_2 = (\ ?\ )_{10}$

2^5 2^4 2^3 2^2 2^1 2^0

32 16 0 4 0 1

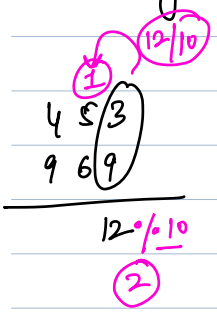
$= 53$

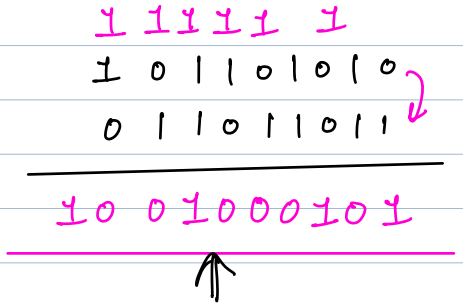
Quiz 2

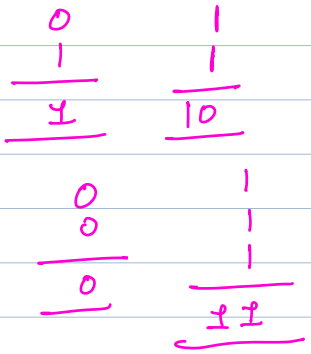
2	172	0
2	86	0
2	43	1
2	21	1
2	10	0
2	5	1
2	2	0
	1	

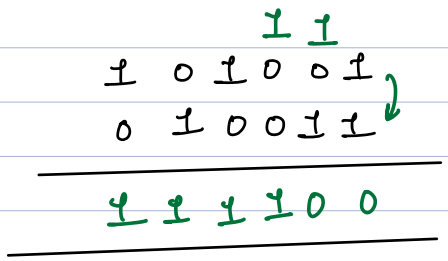
$(10101100)_2$

Binary addition

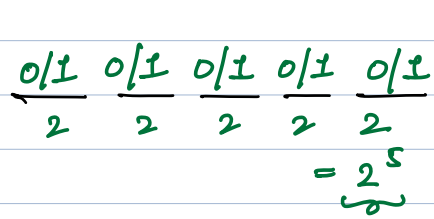


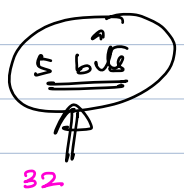






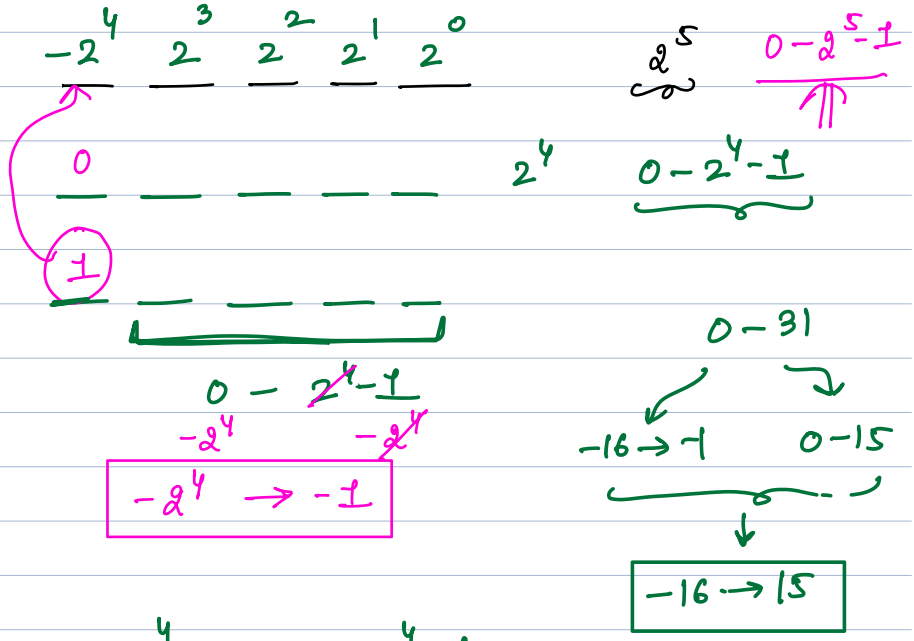
whole numbers





$0 - 31 \Rightarrow \boxed{0 - 2^5 - 1}$

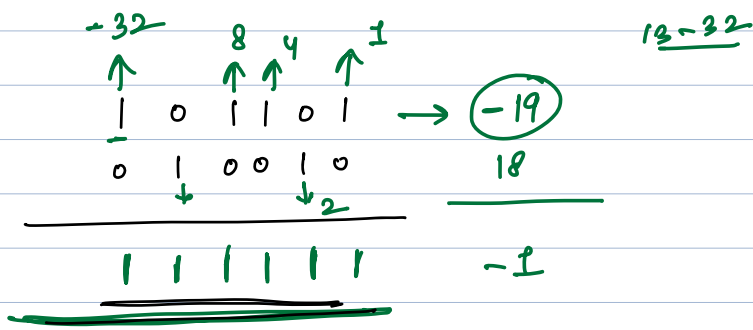
n bits $\rightarrow$ $2^n \Rightarrow \boxed{0 - 2^n - 1}$



5 bits $\quad -2^4 \longrightarrow 2^4-1$

8 bits $\quad -2^7 \longrightarrow 2^7-1$

int $\equiv$ 4 bytes $\equiv$ 32 bits $\Rightarrow$ $\boxed{-2^{31} \longrightarrow 2^{31}-1}$



2's compliment :- represent -ve numbers to Binary

-10

1's compliment

0 0 0 0 1 0 1 0

1 1 1 1 0 1 0 1

+1

0 0 0 0 0 0 0 1

1 1 1 1 0 1 1 0

-128 64 32 16 0 4 2 0 = -10

-x

x —1's comp→ □ +1 → -x

-25

8 bits

0 0 0 1 1 0 0 1

1 1 1 0 0 1 1 0

+1

1 1 1 0 0 1 1 1 = -25

overflow

1 0 0 1 0

1 0 1 0 0

0-31

18+20 = 38

1 0 0 1 1 0 → 6

Bitwise operators

&, |, ^, ~, <<, >>

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

a = 29, b = 18

- a & b → 16
- a | b → 31
- a ^ b → 15

```
 11101   a
 10010   b
-----
 10000
-----
 11111   a|b
-----
 01111   a^b
-----
```

Properties

- A ^ 1 → even: 0, odd: 1

This helps me to figure out if 0th bit is set/unset!

```
  10110 0          10110 1
& 00000 1        & 00000 1
-------          -------
  00000 0          00000 1
```

- A ^ A = 0
- A ^ 0 = A

```
  10 1011          10 1011
  10 1011        ^ 00 0000
---------        ---------
  00 0000          10 1011
---------        ---------
```

0

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

left shift

$a << 1$

0 0 | 0 | 0 1 1 = 43 (*2)

0 1 0 1 0 1 1 0 = 86

$a << 1 = a * 2$

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

$a << 3 = a * 2^3$

$$a << i = a * 2^i$$

32 bits

$1 << 34 = 2^{34}$

$a = 1$

$$1 << i = 2^i$$

0 0 0 0 1

$1 << 2$ 0 0 1 0 0 2^2

4

Right shift

$$a >> i = a / 2^i$$

0 1 0 1 1 0 1 0 (1)

(0) 1 0 1 1 0 1 0 → X

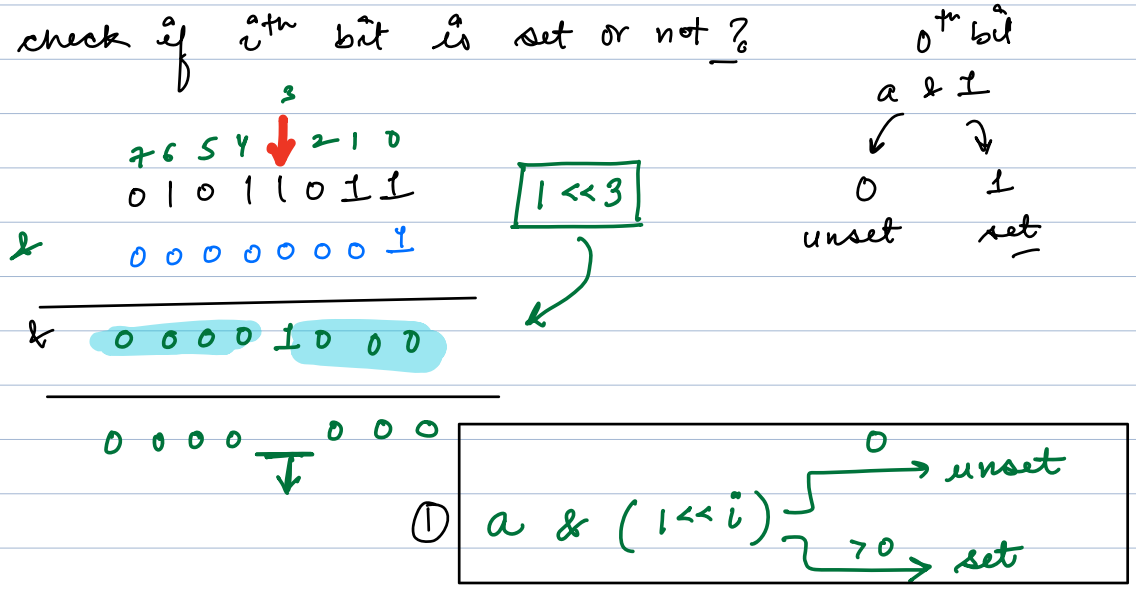
x

$x/2$ → integer division

keep on doing right shifts

0 0 0 0 0 0 0 0 (0)

check if i^{th} bit is set or not ?



Q count total set bits in a number No → +ve inf

```
for( int i=0; i<32; i++)
{
    if( a & (1<<i) != 0)
        cnt++;
}
```

0 1 1 0 1 0 1 → a>>1

```
0 1 1 0 1 0 1      cnt = 1
0 0 1 1 0 1 0      a>>1
0 0 0 1 1 0 1      cnt = 2
0 0 0 0 1 1 0
0 0 0 0 0 1 1      cnt = 3
0 0 0 0 0 0 1      cnt = 4
0 0 0 0 0 0 0
```

```
(2) while( a > 0)                          O(bits) → O(log2 N)
    {
        if( a & 1 == 1)
            cnt++;

        a = a>>1;   // a = a/2;
    }
```

Q Array of size N. Every number occurs twice/even except for 1 number. Find this unique number.

3 1 3 4 4 5 1 6 7 6 7

a ^ a = 0

Take xor of complete array

T.C: O(N), S.C: O(1)

n^2 → freq HM { O(n) – T.C, O(n) S.C

```
{
    ans = 0;
    for(i = 0; i < n; i++)
        ans ^= a[i];
    return ans;
}
```

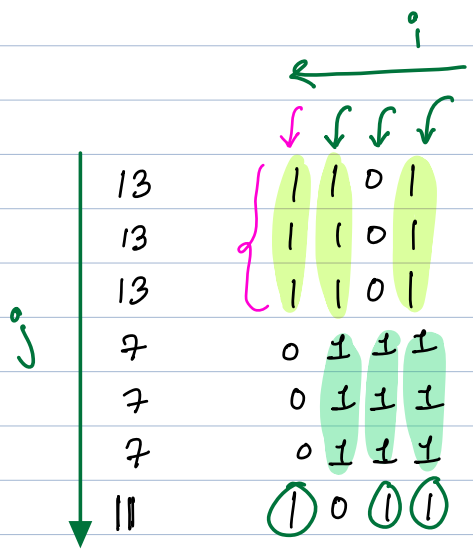
Q Array of size N. Every element occurs thrice / (odd) except for one number. Find this unique number.

(no of times)

1 2 1 3 2 1 3 2 5 3

freq Hashmap

T.C : O(N)
S.C : O(N)



In how many no i^{th} bit is set

3*x — unset

+ unique no

3x + 1

set

3*x+1

ans = 0;

for(i=0; i<32; i++) → location

{

int cnt = 0;

for(j=0; j<n; j++)

{

if(arr[j] & (1<<i) != 0)

cnt++;

}

if(cnt % 3 != 0) — 2^i

ans = ans + (1<<i);

}

T.C: O(n*32)

S.C: O(1)