Bit - Manipulation

* Operators

① AND

a	b	a&b
0	0	0
0	1	0
1	0	0
1	1	1

(both should be true in AND)

* when you &1 with any number, digits remains the same

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

② OR

a	b	a OR b
0	0	0
0	1	1
1	0	1
1	1	1

In OR anyone should be true, both true is also true otherwise it is false.

③ XOR (^) (if & only if)

exclusive OR

a	b	a ^ b
0	0	0
0	1	1
1	0	1
1	1	0

In XOR only one should be true otherwise false.

observation :-

$a \wedge 1 = \bar{a}$

Complement means opposite of that number.

$a \wedge 0 = a$

$a \wedge a = 0$

④ complement (~)

$a = 10110$

$\bar{a} = 01001$

Number System

① **Decimal** → 0, 1, 2, ---, 9 Base ⑩

$(357)_{10}$, $(10)_{10}$

② **Binary Numbers:-**

0 & 1 Base ②

$(10)_{10} = (1010)_2$

$(7)_{10} = (111)_2$

③ **octal** → 0, 1, 2, 3, ---, 7 Base ⑧

Decimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, ---

octal :- 0, 1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13, 14, 15, 16, 17, 20, ----

8 & 9 does not exist in octal.

$(9)_{10} = (11)_8$

④ **Hexadecimal:-**

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

Base ⑯

$(10)_{10} = (A)_{16}$, $(12)_{10} = (C)_{16}$

Conversations:

① Decimal to base b

Q: Convert $(17)_{10}$ to base 2

keep dividing by base, take remainders, write it in opposite.

$$
\begin{array}{r|l}
2 & 17 \\
2 & 8 \quad - 1 \\
2 & 4 \quad - 0 \\
2 & 2 \quad - 0 \\
2 & 1 \quad - 0 \\
 & 1
\end{array}
$$

$(10001)_2 = (17)_{10}$

a →

	1	0	0	0	1

$(17)_{10} = (\ ?\ )_8$

$$
\begin{array}{r|l}
8 & 17 \\
 & 2 \quad - 1
\end{array}
$$

$(17)_{10} = (21)_8$

② Convert any base b to decimal

$(10001)_2 = (\quad)_{10}$?

Steps:- multiply & add the Power of base with digits.

$2^0 \times 1 + 2^1 \times 0 + 2^2 \times 0 + 2^3 \times 0 + 2^4 \times 1 = 1 + 16$
$= 17$

$(10001)_2 = (17)_{10}$

Q:- $(21)_8 = (\ )_{10}$

$$8^0 \times 1 + 8^1 \times 2 = 1 + 16$$
$$= 17$$

$$(21)_8 = (17)_{10}$$

If we want to convert base 2 to base 8 then convert the base 2 into decimal & then decimal to base 8.

Continuing with operators:-

5. Left Shift operator (<<)

$$(10)_{10} = (1010)_2$$

$$10 << 1$$

Step: $1010 << 1 = 10100$

$\underbrace{10100}_{\text{New number}}$

$$= 2^0 \times 0 + 2^1 \times 0 + 2^2 \times 1 + 2^3 \times 0 + 2^4 \times 1$$
$$= 0 + 0 + 4 + 0 + 16$$
$$= 20$$

$$\boxed{\therefore\ a << 1 = 2a}$$

The left shift operator will double that number. (increasing it's entire base)

General Point :-

$$\boxed{a << b = a * 2^b}$$

6 Right shift : >>

Q: $001100\underbrace{1}_{\text{ignored}} >> 1 \Rightarrow 001100$

$(\underbrace{009}_{\text{(ignored)}}11234)_{10} = (11234)_{10}$

(ignored) ⇒ Same for all number system

$$\boxed{a >> b = \frac{a}{2^b}}$$

Questions :-

1. Given a no. find if it is even or odd

Point :- Every no. is calculated in binary form internally.

$12 + 7 \Rightarrow$

$$\begin{array}{r} 1100 \\ +\ 0111 \\ \hline 10011 \end{array}$$

$(19)_{10} = (10011)_2$

$2^0 \times 1 + 2^1 \times 1 + 2^4 \times 1 = 1 + 2 + 16$
$= 19$

Note:-

1001 | 1 → leaving this, every other is a power of 2

→ 2^0

This will always be even

Hence:- if 2^0 place == 1 ⟹ odd

otherwise ⟹ even

100101 → least significant bit

& 0000001

---

0 0 0 0 0 1 → (1) Hence odd

$\underbrace{0\ 0\ 0\ 0\ 0}_{\text{ignored}}$

Sum up:- n & 1 == 1 ⟹ odd else even

Q2 :-

arr = [2, 3, 4, 1, 2, 1, 3, 6, 4]

→ ans

0

All duplicates will be 0

because $a \wedge a = 0$

Ans:- XOR all the nos.

Q3 Find ith bit of a number

8 7 6 5 4 3 2 1
1 0 1 1 0 1 1 0

?

Ans:-
1 0 1 1 0 1 1 0
& 0 0 0 1 0 0 0 0

---

0 0 0 1 0 0 0 0 Ans

This is called a mask

n => mask with n-1 zero's
left shift will be used to add zero's

$1 << 4 \Rightarrow 10000$

Ans :- $n \& (1 << (n-1))$

Q Set the ith bit
> Turn it to 1

$$\begin{array}{r} 4\text{th} \\ 10\,1\,0110 \\ \text{OR}\ 0001000\,0 \\ \hline 1011\,1\,110 \end{array}$$

0001000 → mask

Q Reset ith bit:-

1 -> 0
0 -> 0

$$\begin{array}{r} 1010110 \\ \&\ 1101111 \\ \hline 1000110 \end{array}$$

1101111 → ~~1100~~ to get this mask

mask : ~(1 << (n-1))

Q Find the position of the right most set bit.

ex :- 10110110

The first one '1' that occurs from the right hand side i.e. 2

Negative of a number in Binary form :-

1 byte = 8 bits

value of no.

$10 \Rightarrow$ | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |

most significant bit

least significant bit

Tell us if no. is +ve or -ve

1 → -ve
0 → +ve

-10 = ?

steps : ① complement of no.

② +1 to it

This is also known as 2's complement

$(10)_{10} = (00001010)_2$

① 11110101

② 11110101
$+ \quad 1$

$(11110110)_2 = (-10)$

Range of a Number :-

① 1 byte :

0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1

→ sign of a number

Total = 2× 2× 2× --- 8 times
= 256

Actual no. is stored in bits = n−1
total bits

1 byte = 7 bits

Total I can make from 7 bits
$= 2^7 = 128$

−128 to 127
└ 0 is here as well

Range formula :- for n bits

$$\boxed{-2^{n-1} \text{ to } 2^{n-1}-1}$$