

quiz

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

| 2 | 45 | |
|---|----|---|
| 2 | 22 | 1 |
| 2 | 11 | 0 |
| 2 | 5 | 1 |
| 2 | 2 | 1 |
| 2 | 1 | 0 |
| | 0 | 1 |

Bitwise operators

\Rightarrow $\&$, $|$, \wedge , \sim

$\&$ bitwise AND
 $|$ bitwise OR
 \wedge XOR
 \sim invert

$<<$, $>>$

SOPAn (13110); 15

$$\begin{array}{r}
 1101 \\
 \text{OR } 1010 \\
 \hline
 1111 \rightarrow 15
 \end{array}$$

`solve(13 & 10);` 8

$$\begin{array}{r} 1101 \\ \text{AND } 1010 \\ \hline 1000 \end{array} \rightarrow 8$$

`solve(13 ^ 10);` 7

$$\begin{array}{r} 1101 \\ \text{XOR } 1010 \\ \hline 0111 \end{array} \rightarrow 7$$

`solve(15 << 3);` 120

$$a \ll N = (2^N) a$$

$$1 \ll N = 2^N$$

`solve(35 >> 3);` 4

$$a \gg N = a / 2^N$$

Some applications of left shift

$n = 45$

| | | | | | |
|---|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 |

$1 < 3$ Ans

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 | 0 |
|---|---|---|---|---|---|

$n = 45$

| | | | | | |
|---|---|---|---|---|---|
| 5 | 4 | 3 | 2 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 |

$1 < 4$ Ans

| | | | | | |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|

ON / set \rightarrow bit is 1

OFF / unset \rightarrow bit is 0

boolean checkBit (int n, int i)

// check whether i^{th} indexed bit in n is on or not

if ((n & (1 << i)) == 0) {

 return false;

}

else {

 return true;

}

}

TC: $O(1)$

$n = 19$

$i = 3$

n :

| | | | | |
|---|---|---|---|---|
| 4 | 3 | 2 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 |

$1 < 3$:

| | | | | |
|---|---|---|---|---|
| 0 | 1 | 0 | 0 | 0 |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|

$n = 19$

$i = 1$

n :

| | | | | |
|---|---|---|---|---|
| 4 | 3 | 2 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 |

$1 < 1$:

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
|---|---|---|---|---|

$$\begin{array}{r}
 n = 45 \quad \begin{array}{cccccc} 5 & 4 & 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 \end{array} \\
 1 \ll 3 \quad \text{OR } \begin{array}{cccccc} 0 & 0 & 1 & 0 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccccc} 1 & 0 & 1 & 1 & 0 & 1 \end{array}
 \end{array}$$

$$\begin{array}{r}
 n = 45 \quad \begin{array}{cccccc} 5 & 4 & 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 \end{array} \\
 1 \ll 4 \quad \text{OR } \begin{array}{cccccc} 0 & 1 & 0 & 0 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccccc} 1 & 1 & 1 & 1 & 0 & 1 \end{array}
 \end{array}$$

$n | (1 \ll i) \rightarrow$ set the i^{th} indexed bit in n .

```

int setbit (int n, int i) {
    // set ith bit in n
    n = n | (1 << i);
    return n;
}

```

$$n = 9, \quad i = 2$$

$$\begin{array}{r}
 9 : \quad \begin{array}{cccc} 3 & 2 & 1 & 0 \\ 1 & 0 & 0 & 1 \end{array} \\
 1 \ll 2 : \quad \begin{array}{cccc} 0 & 1 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccc} 1 & 1 & 0 & 1 \end{array}
 \end{array}$$

$$\begin{array}{r}
 n = 45 \quad \begin{array}{cccccc} 5 & 4 & 3 & 2 & 1 & 0 \\ & 1 & 0 & 1 & 1 & 0 & 1 \end{array} \\
 1 \ll 3 \quad \text{XOR} \quad \begin{array}{cccccc} & 0 & 0 & 1 & 0 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccccc} & 1 & 0 & 0 & 1 & 0 & 1 \end{array}
 \end{array}$$

$$\begin{array}{r}
 n = 45 \quad \begin{array}{cccccc} 5 & 4 & 3 & 2 & 1 & 0 \\ & 1 & 0 & 1 & 1 & 0 & 1 \end{array} \\
 1 \ll 4 \quad \text{XOR} \quad \begin{array}{cccccc} & 0 & 1 & 0 & 0 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccccc} & 1 & 1 & 1 & 1 & 0 & 1 \end{array}
 \end{array}$$

$n \wedge (1 \ll i) = \text{toggle / flip } i^{\text{th}} \text{ bit}$

```
int flipbit (int n, int i) {
```

// in n flip bit at ith index

```
    n = n ^ (1 << i);
```

```
    return n;
```

}

$n = 10$

$i = 2$

$$\begin{array}{r}
 10 : \quad \begin{array}{cccc} 3 & 2 & 1 & 0 \\ & 1 & 0 & 1 & 0 \end{array} \\
 1 \ll 2 : \quad \begin{array}{cccc} & 0 & 1 & 0 & 0 \end{array} \\
 \hline
 \begin{array}{cccc} & 1 & 1 & 1 & 0 \end{array}
 \end{array}$$

Q-1 Given an integer n and i , unset the i th indexed bit in n number.

$n = \begin{matrix} 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 0 \end{matrix} \quad i = 1$
 \downarrow
 $ans = 1000 \Rightarrow 8$

$n = \begin{matrix} 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 0 \end{matrix} \quad i = 2$
 \downarrow
 $ans = 1010$

$n \& (1 << i) \rightarrow$ check bit at i th index in n

$n | (1 << i) \rightarrow$ set bit at i th index in n

$n \wedge (1 << i) \rightarrow$ flip bit at i th index in n

checkbit(n, i)
 \swarrow on flip (xor)
 \searrow odd do nothing

Q.2 Given a no. n , count total no. of **set bits**.
 bits which are 1.

| n | ans |
|------------|-----|
| 10 (1010) | 2 |
| 0 (0000) | 0 |
| 17 (10001) | 2 |
| 13 (1101) | 3 |

T.C: $O(1)$

int: 4 bytes (1 byte = 8 bits)

int: 32 bit

idea: go on every bit from $i=0$ to $i=31$,
 then $\text{checkbit}(n, i) == \text{true}$
 $\rightarrow \text{cnt}++;$

int countSetBits (int n) {

// return total no. of on/set bit in n

int count = 0;

for (int $i=0$; $i \leq 31$; $i++$) {

if ($\text{checkbit}(n, i) == \text{true}$) {

count++;

}

}

return count;

}

$n = 45$

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

| i | cnt |
|-----|-----|
| 0 | 1 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 4 | 3 |
| 5 | 4 |
| ... | ... |
| 31 | 4 |

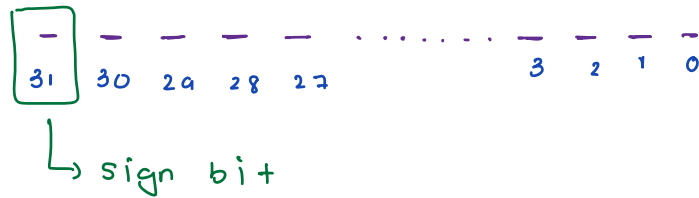
T.C: $O(1)$

int: 32

Dealing with negative numbers

int: 32 bits

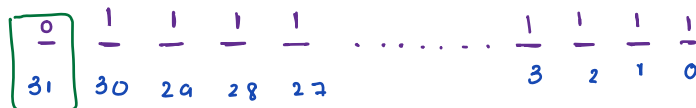
long: 64 bits



sign bit is 1 (for -ve no.)

sign bit is 0 (for +ve no.)

max +ve value



$$2^0 + 2^1 + 2^2 + 2^3 + \dots + 2^{30}$$

h.p

$$a = 1$$

$$r = 2$$

$$t = 31$$

$$S_t = \frac{a(r^t - 1)}{r - 1}$$

$$= \frac{1(2^{31} - 1)}{1} = 2^{31} - 1$$

$$\text{int (roughly)} \Rightarrow -10^9 \text{ to } 10^9$$

$$\text{int (accurate)} \Rightarrow -2^{31} \text{ to } 2^{31} - 1$$

How to convert -ve int no. to binary:

- i) convert positive equivalent of the no. to binary.
- ii) flip all bits
- iii) add a 1.

Note: let's understand the concept in 8 bits form rather than 32 bits (logic is absolutely same)

$$n = -13$$

$$00001101 \rightarrow 13$$

$$11110010$$

$$+ \quad \quad \quad 1$$

$$\begin{array}{r} \text{sign bit } \boxed{1} \quad 1 \quad 1 \quad 1 \quad 0 \quad 0 \quad 1 \quad 1 \\ \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \quad \downarrow \quad \downarrow \\ -128 + 64 + 32 + 16 \quad + 2 + 1 \end{array}$$

$$-128 + 64 + 32 + 16 + 2 + 1 = -13$$

min int value

$$\begin{array}{c} \boxed{1} \\ 31 \end{array} \quad \begin{array}{c} 0 \\ 30 \end{array} \quad \begin{array}{c} 0 \\ 29 \end{array} \quad \begin{array}{c} 0 \\ 28 \end{array} \quad \begin{array}{c} 0 \\ 27 \end{array} \quad \dots \quad \begin{array}{c} 0 \\ 3 \end{array} \quad \begin{array}{c} 0 \\ 2 \end{array} \quad \begin{array}{c} 0 \\ 1 \end{array} \quad \begin{array}{c} 0 \\ 0 \end{array}$$

$$n = -45$$

00101101 (45 in 8 bit format)

11010010

+ 1

11010011

$$\begin{array}{ccccccc}
 \boxed{1} & 1 & 0 & 1 & 0 & 0 & 1 \\
 \downarrow & \downarrow & & \downarrow & & \downarrow & \downarrow \\
 -128 & +64 & + & 16 & + & 2 & +1 \\
 & & & & & & = -128 + 83 \\
 & & & & & & = -45
 \end{array}$$

45: 00000000 00000000 00000000 00101101

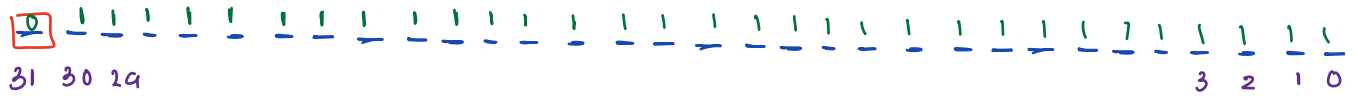
-45: $\boxed{1}$ 11111111 11111111 11111111 010011

\downarrow
 -2^{31}

(32 bit format)

Doubts
=

int: 32 bit



max int val

$$2^0 + 2^1 + 2^2 + 2^3 + \dots + 2^{30}$$

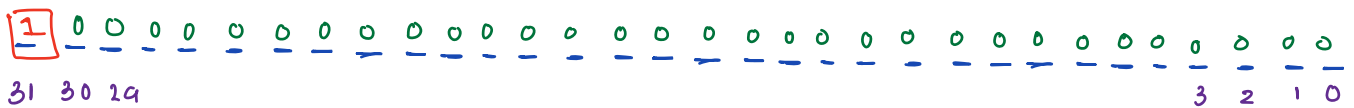
$$a = 1$$

$$r = 2$$

$$t = 31$$

$$\frac{1(2^{31} - 1)}{2 - 1} = 2^{31} - 1$$

min int val



$$-2^{31}$$

$$-2^{31} \text{ to } 2^{31} - 1$$