

Bit Manipulation

int n = 2;

4bit \rightarrow nibble

① 0 - 15
x negative

② -ve
numbers

-0

③ MSB - Sign

0

-ve

1111

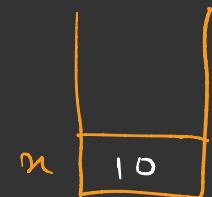
0000

1

0001

-1

10



10000 -8
1001 -7

1010 -6

1011 -5

1100 -4

1101 -3

1110 -2

1111 -1

1000

0000

0001

0010

0011

0100

0101

0110

0111

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

1 1 1 1
0 0 0 0
① 1's complement
2's complement

2 ② add 1

0111
1

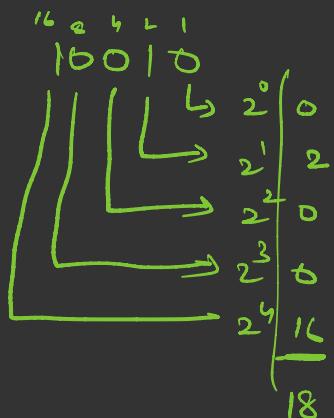
1000
1000
2 0
4 0
8 8
8

D → B

(18)₁₀

$$\langle 10010 \rangle_2$$

$$\begin{array}{r}
 18 \\
 \times 2 \\
 \hline
 36
 \end{array}$$



$$\begin{array}{lllll} \text{byte} & \overset{8 \text{ bits}}{\Rightarrow} & -2^7 & \text{to} & 2^7 - 1 \\ \text{short} & \overset{16 \text{ bits}}{\Rightarrow} & -2^{15} & \text{to} & 2^{15} - 1 \end{array}$$

int 32 bits -2^{31} to $2^{31} - 1$

long by bits - 2^{63} to $2^{63} - 1$

0 0 0 0 0 , " 10

Decimal - binary
base 10 base 2

$$581 \Rightarrow 5 \times 10^2 + 8 \times 10^1 + 1 \times 10^0$$

+ve

- ① Convert normally
- ② Fit to bits

-ve

- ① Convert normally
- ② Fit to bits
- ③ 2's compliment

Binary → Decimal
base - 2

+ve

- ① MSB = 0
- ② Convert

-ve

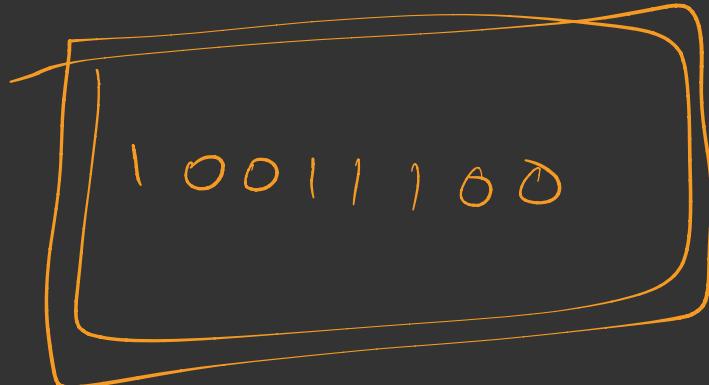
- ① MSB = 1
- ② 2's compliment
- ③ Convert
- ④ -ve sign

byte a = (byte) 156;

Sys0 ≥ 12

-128 to 127

-2⁷ to 2⁷ - 1



10011100
01100011
1

Sys0(a)

01100100
128 64 32 16 8 4 2 1

-100

64 + 32 + 4

Bitwise Operators

& | ^ ~ << >> >>>

① And (&)

$a \& b$

0	0	0
0	1	0
1	0	0
1	1	1

$$a \& 0 \Rightarrow 0$$

$$a \& 1 \Rightarrow a$$

$$\begin{array}{r} 1011 & 11 \\ 0110 & 6 \\ \hline 0010 & 2 \end{array}$$

OR (|)

$a | b$

0	0	0
0	1	1
1	0	1
1	1	1

$$a | 1 \Rightarrow 1$$

$$a | 0 \Rightarrow a$$

1011

$$\begin{array}{r} 1011 \\ 0110 \\ \hline \cancel{01111} \end{array}$$

③ XOR (^)

$a \wedge b$

0	0	0	$a \wedge 0 \Rightarrow a$
0	1	1	$a \wedge 1 \Rightarrow \sim a$
1	0	1	
1	1	0	

000000101

000000111

$$\begin{array}{r} 000000101 \\ 000000111 \\ \hline \cancel{000000010} \\ \Rightarrow 2 \end{array}$$

$$a \wedge a \Rightarrow 0$$

③ \sim 's Compliment

$\sim a$

$\sim 0 \Rightarrow 1$

$\sim 1 \Rightarrow 0$

~ 2

000000010

111111101

④ Left Shift ($<<$)

$a = \underbrace{1 0 1 1}_{11} \underbrace{0 1 0 0}_{00}$

$a << 2$

$a << 4$

0100 0000

$\xrightarrow{\quad << 1 \quad}$

1 0 0 0 0 1

2 0 0 0 0 1 0

4 0 0 0 1 0 0

8 0 0 1 0 0 0

$1 << a \Rightarrow 2^a$

101 << 1

$[a << 1 \Rightarrow 2a]$

1010

⑤ Right shift >>

$a = 01000111 \quad a \gg 2$

00010001

$b = 10110110 \quad b \gg 2$

11101101

⑥ Triple right shift >>>

new bits are always 0

Only 0 is added on left

$a = 01000111 \quad a \gg 2$

00010001

$b = 10110110 \quad b \gg 2$

00101101

Ques Turn ith bit on (convert to 1)

$n, i=4$

$$\begin{array}{r}
 \text{8 7 6 5 4 3 2 1} \\
 | 0 1 1 0 0 1 0 \Rightarrow \\
 | \underline{0 0 0 0 1 0 0 0} \\
 | 0 1 1 1 0 1 0
 \end{array}$$

$$\begin{array}{r}
 1101 \\
 0010 \\
 \hline
 1111
 \end{array}$$

(3)

$0 0 0 0 1 0 0 0$

$1 \ll 3$

i^{th}
 $(i-1)$ times

$$\begin{array}{r}
 0 0 0 0 0 0 0 1 \\
 0 0 0 0 1 0 0 0
 \end{array}$$

Ques Turn ith bit off (make ith bit 0)

$n, i=3$

$$\begin{array}{r}
 \text{8 7 6 5 4 3 2 1} \\
 | 0 0 1 0 1 1 0 \\
 | \underline{1 1 1 1 1 0 1 1} \\
 | 0 0 1 0 0 1 0
 \end{array}$$

$$\begin{array}{r}
 1 1 1 1 0 1 1 \\
 0 0 0 0 0 1 0 0
 \end{array}$$

mask \Rightarrow \sim mask

$$\sim (1 \ll (i-1))$$

Ques toggle the i th bit

$$n, i = s \quad \begin{smallmatrix} 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 1 \end{smallmatrix}$$

$$a \wedge 0 = a$$

$$a \wedge 1 = \sim a$$

$$\begin{array}{r} n \quad 00010000 \\ \hline \sim n \quad 10100101 \end{array}$$

Ques Check i th bit $n, i = 6$

$$\begin{array}{r} n \quad \begin{smallmatrix} 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \end{smallmatrix} \\ \begin{array}{l} 1 - \text{true} \\ 0 - \text{false} \end{array} \quad \begin{array}{l} 8 \\ 00100000 \end{array} \\ \hline 00100000 \end{array}$$

Ques Find if number is odd or even

$$\begin{array}{c} \text{MSB} \curvearrowleft 10110010 \curvearrowright \text{LSB} \\ \text{LSB} = 0 \Rightarrow \text{even} \\ \text{LSB} = 1 \Rightarrow \text{odd} \end{array}$$

n & l

$$\begin{array}{r} 1000 \\ 0001 \\ \hline \end{array}$$

$$\begin{array}{r} 1111 \\ - \\ 1110 \\ | \\ 122 \\ | \\ 44 \\ 88 \\ \hline 14 \end{array}$$