

$\text{Base} = 10$   
 decimal  
 $[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]$

$$\begin{array}{r}
 8317 \\
 + 300 \\
 + 10 \\
 + 7 \\
 \hline
 8 \times 10^3 + 3 \times 10^2 + 1 \times 10^1 + 7 \times 10^0
 \end{array}$$

Octal number system  $= [0, 1, 2, 3, 4, 5, 6, 7]$

$\text{Base} = 8$

$$\begin{aligned}
 (0132)_8 &= 0 \times 8^3 + 1 \times 8^2 + 3 \times 8^1 + 2 \times 8^0 \\
 &= 0 + 64 + 24 + 2 = (90)_{10}
 \end{aligned}$$

Ternary number system  $= [0, 1, 2]$   
 $\text{Base} = 3$

$$\begin{aligned}
 (1120)_3 &= 1 \times 3^3 + 1 \times 3^2 + 2 \times 3^1 + 0 \times 3^0 = ( )_{10} \\
 &= 27 + 9 + 6 + 0 \\
 &= (42)_{10}
 \end{aligned}$$

number  
 ↓ multiply with  
 decimal power of base

$$\begin{array}{ccccccc}
 & 10^4 & 10^3 & 10^2 & 10^1 & 10^0 \\
 \leftarrow 5^{th} & \uparrow & \uparrow & \uparrow & \uparrow & \uparrow \\
 & 2^{nd} & 2^{nd} & 1^{st} & & 
 \end{array}$$

$$\begin{array}{c}
 x^{th} \\
 \downarrow \\
 10^{x-1}
 \end{array}$$

$$\begin{aligned}
 (125)_8 &= 1 \times 8^2 + 2 \times 8^1 + 5 \times 8^0 \\
 &= 64 + 16 + 5 \\
 &= (85)_{10}
 \end{aligned}$$

$$\begin{aligned}
 (02101)_3 &= 0 \times 3^4 + 2 \times 3^3 + 1 \times 3^2 + 0 \times 3^1 + 1 \times 3^0 \\
 &= 0 + 54 + 9 + 0 + 1 \\
 &= (64)_{10}
 \end{aligned}$$

$$\begin{aligned}
 \text{Base} &= x \\
 &\downarrow \\
 &0 - x^{-1}
 \end{aligned}$$

Hexadecimal :- 0-9, A-F

Base = 16

A	-	10
B	-	11
C	-	12
D	-	13
E	-	14
F	-	15

Binary Number system - [0, 1]

Base = 2

$$(10110)_2 =$$

$$\begin{array}{r|l}
 1 & 2^4 \\
 0 & 2^3 \\
 1 & 2^2 \\
 1 & 2^1 \\
 0 & 2^0 \\
 \hline
 & 16 \\
 & 0 \\
 & 4 \\
 & 2 \\
 & 0 \\
 \hline
 & (22)_{10}
 \end{array}$$

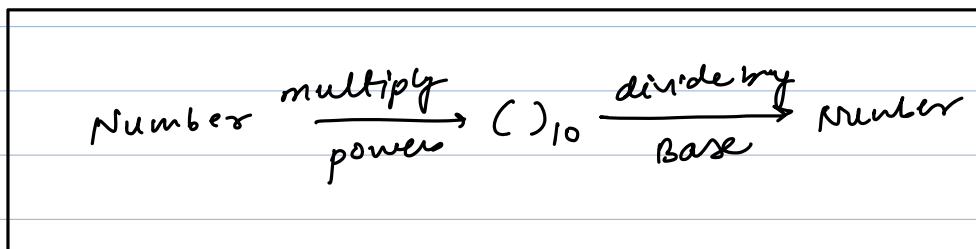
## Decimal to Binary

divide by Base  
rema — 0 - Base - 1

$$(28)_{10} \Rightarrow (?)_2$$

2	28	0
2	14	0
2	7	1
2	3	1
	1	

$(11100)_2$



$$(37)_{10} =$$

2	37	1
2	18	0
2	9	1
2	4	0
2	2	0
	1	

$(100101)_2$

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

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

$(11001)_2$

# • Addition

$$\begin{array}{r}
 14/10 \quad 12/10 \quad 1 = 13/10 \\
 2 \quad 4 \quad 3 \quad 7 \\
 + \quad 6 \quad 9 \quad 8 \quad 6 \\
 \hline
 \end{array}$$

decimal

$$\begin{array}{r}
 9 \cdot /10 \quad 14 \cdot /10 \quad 12 \cdot /10 \quad 13 \cdot /10 \\
 \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\
 9 \quad 4 \quad 2 \quad 3
 \end{array}$$

Binary add<sup>n</sup>  
2 Ring

$$\begin{array}{r}
 0 \quad 0 \\
 1 \quad 0 \\
 \hline
 0 \quad 4 \quad 0 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 1 \\
 1 \\
 1 \\
 \hline
 1 \quad 1
 \end{array}$$

$$\begin{array}{r}
 1/2 \quad 3/2 \quad 2/2 \quad 1/2 \\
 1 \quad 0 \quad 1 \quad 1 \quad 0 \\
 0 \quad 0 \quad 1 \quad 1 \quad 1
 \end{array}$$

→ 22  
→ 7

$$\begin{array}{r}
 1 \cdot /2 \quad 1 \cdot /2 \quad 2 \cdot /2 \quad 1 \cdot /2 \quad 1 \cdot /2 \\
 \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow \\
 1 \quad 1 \quad 1 \quad 0 \quad 1
 \end{array}$$

→ 29

$$\begin{array}{r}
 1 \quad 1 \\
 1 \quad 0 \quad 0 \quad 1 \quad 1 \quad \rightarrow 19 \\
 0 \quad 1 \quad 0 \quad 0 \quad 1 \quad \rightarrow 9
 \end{array}$$

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

→ 28

# Bitwise operations

( $\&$ ,  $|$ ,  $\wedge$ ,  $\sim$ ,  $\ll$ ,  $\gg$ )  
 $\downarrow$   $\downarrow$   $\downarrow$   $\downarrow$   $\downarrow$   
 AND OR XOR NOT left shift right shift

1  $\rightarrow$  set bit  
 0  $\rightarrow$  unset bit

a	b	$a \& b$	$a   b$	$a \wedge b$	$\sim a$ (toggle)
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0

$$a = 3$$

$$b = 4$$

a    0 1 1  
 b    1 0 0

$a \& b$	0 0 0	= 0
$a   b$	1 1 1	= 7
$a \wedge b$	1 1 1	= 7

$$a = 13$$

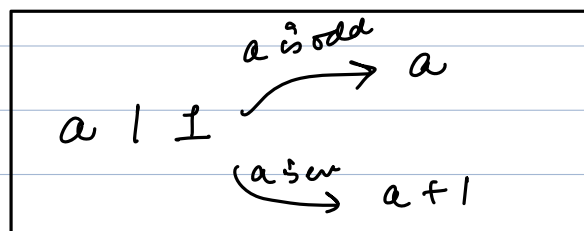
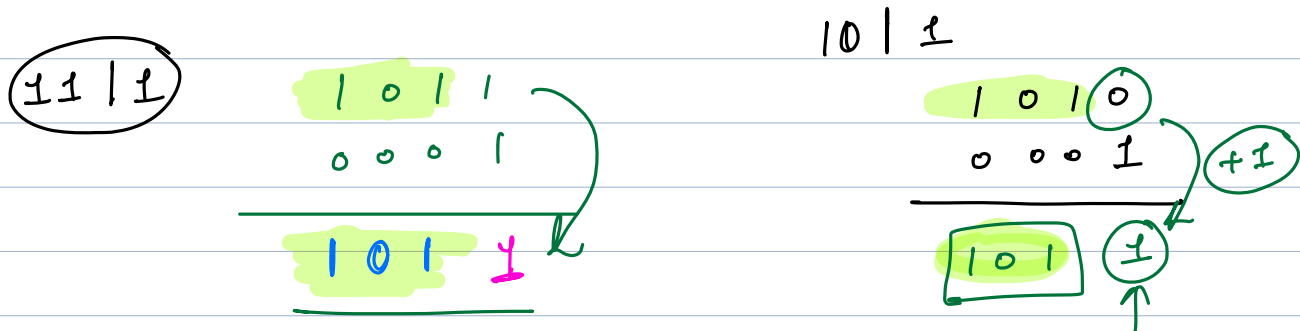
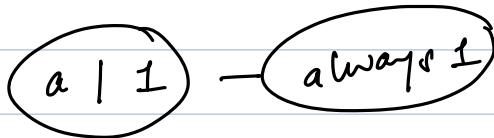
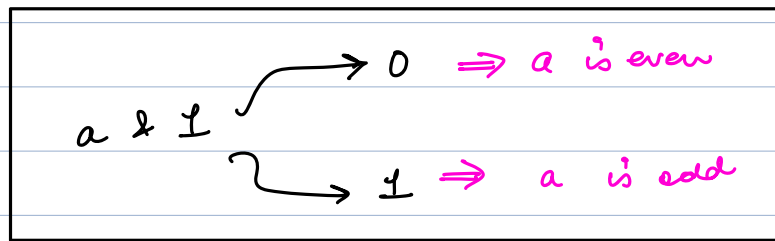
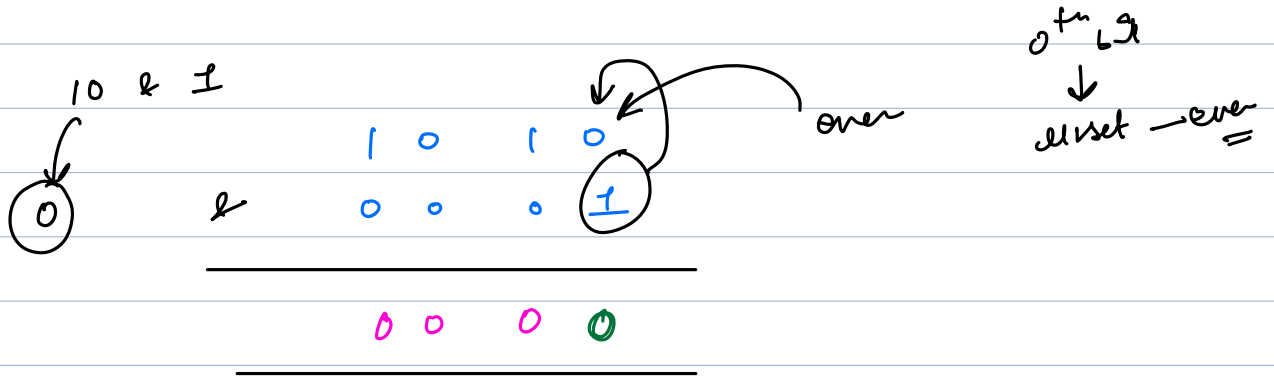
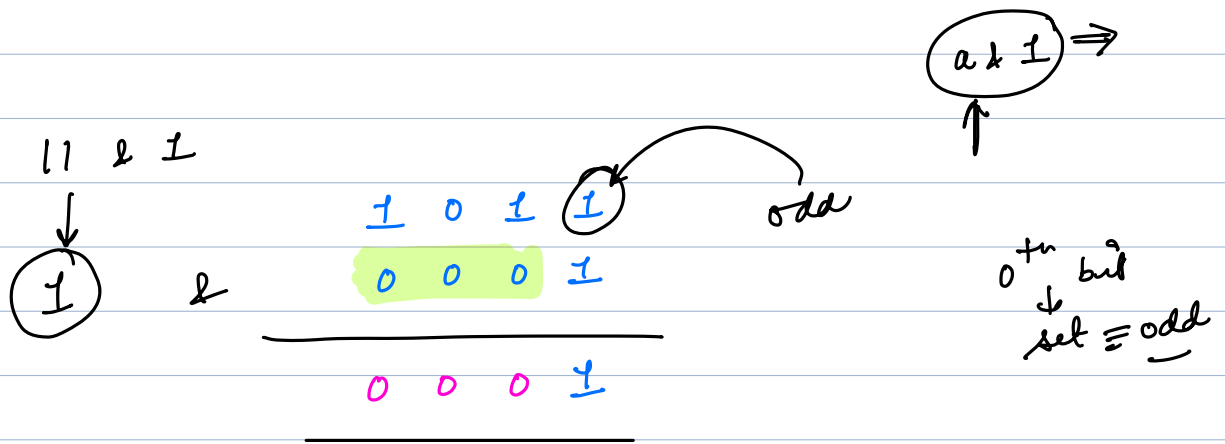
$$b = 10$$

1 1 0 1

1 0 1 0

$a \& b$	1 0 0 0	$\rightarrow$ 8
$a   b$	1 1 1 1	$\rightarrow$ 15
$a \wedge b$	0 1 1 1	$\rightarrow$ 7

10 : 30  
 $\uparrow$



$$\underline{a \wedge 1 = ?}$$

$$\begin{array}{r} 11^1 1 \\ \underline{1011} \\ 0001 \\ \hline 1010 \end{array}$$

$$\begin{array}{r} 10^1 1 \\ \underline{1010} \\ 0001 \\ \hline 1011 \end{array}$$

$$\begin{array}{l} \text{odd} \quad a-1 \\ a \wedge 1 \\ \text{even} \quad a+1 \end{array}$$

$$a \& a = a$$

$$a | a = a$$

$$a \wedge a = 0$$

$$a \wedge 0 = a$$

$$\begin{array}{r} a = 11011101 \\ \wedge a = 11011101 \\ \hline (a) \quad 11011101 \end{array}$$

$$\begin{array}{r} a = 101101011 \\ 0 = 000000000 \\ \hline 101101011 \end{array}$$

$$\left\{ \begin{array}{l} a \& b = b \& a \\ a | b = b | a \\ a \wedge b = b \wedge a \end{array} \right\}$$

$$\begin{aligned} a \wedge b \wedge c &= a \wedge (b \wedge c) = (a \wedge b) \wedge c \\ &= (a \wedge c) \wedge b \end{aligned}$$

$$a \& b \& c = \dots$$

$$a | b | c \dots$$

$$\begin{array}{c} 1 \wedge 0 \quad 1 \\ 0 \quad 0 \end{array}$$

$$120 \wedge 5 \wedge 6 \wedge 6 \wedge 120 \wedge 5$$



$$\cancel{120 \wedge 120} \wedge \cancel{5 \wedge 5} \wedge \cancel{6 \wedge 6} = 0$$

$$a \wedge a = 0$$

$$a \wedge 0 = a$$

Q array of size N. All numbers occurs twice except for one number. Find the unique number.

Microsoft  
Adobe  
Amazon  
etc!

A: ~~2~~ ~~1~~ ~~2~~ ~~5~~ 4 ~~6~~ ~~5~~ ~~6~~ ~~1~~

↓  
xor of whole array

Xor

$$2 \wedge 2 \wedge 1 \wedge 1 \wedge 5 \wedge 5 \wedge 6 \wedge 6 \wedge 4$$

$$ans = 0;$$

for ( i = 0; i < n; i++)  
    ans = ans ^ i;

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

pairs?

all no's occur in even  
except for one odd freq

ans = 0

2	1	4	5	2	1	5
↓	↓	↓	↓	↓	↓	↓
2	3	7	2	0	1	9

↑↑

10	101
01	001
011	100
100	
111	
101	
010	