



Today's agenda

- ↳ Binary number system
- ↳ operators
- ↳ Problems
- ↳ Constraints



AlgoPrep



↳ decimal no. system

↳ {0-9} digits

0 0	1 0	2 0	9 0
0 1	1 1	2 1	9 1
0 2	1 2	2 2	9 2
⋮	⋮	⋮	⋮
0 8	1 9	2 9	9 9
0 9			

↳ Binary number system

↳ {0,1}

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



↳ Conversion

↳ Convert decimal no to binary:

ex: 30

2	30	-	0	↑ → 111110
2	15	-	1	
2	7	-	1	
2	3	-	1	
2	1	-	1	
	0			



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Quiz:

2	45	-	1	↑ → 101101
2	22	-	0	
2	11	-	1	
2	5	-	1	
2	2	-	0	
2	1	-	1	
	0			



↳ binary no. to decimal no. → bit index

ex: $(10101)_2$ → 0 : unset bit / off bit
 1 : set bit / on bit

$1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

↓ add all

$$\rightarrow 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$$

$$\rightarrow 16 + 0 + 4 + 0 + 1 = 21$$

Quiz:

$(1011010)_2$

$$\hookrightarrow 2^1 + 2^3 + 2^4 + 2^6$$
$$2 + 8 + 16 + 64 = 90$$

→ $(101020)_2$: invalid input



4. Add binary numbers

$$\begin{array}{r} 1 1 \\ 368 \\ \underline{454} \\ 822 \end{array}$$

$$\begin{array}{ll} 0+0 \rightarrow 0 & 1+1 \rightarrow 10 \\ 0+1 \rightarrow 1 & 1+1+1 \rightarrow 11 \\ 1+0 \rightarrow 1 & \end{array}$$

①

$$\begin{array}{r} 1 1 1 1 1 1 \\ 010111 \\ \underline{011110} \\ 110101 \end{array}$$

Quiz

$$\begin{array}{r} 1 1 1 1 1 1 1 \\ 0101011 \\ \underline{0100111} \\ 101100 \end{array}$$



Bitwise operators: { ^{← 2}and, ^{← 1}or, ^{← ^}xor, leftshift, rightshift }

A	B	^{0 is dominating} A & B	^{1 is dominating} A B	^{same same Puppy shame} A ^ B
0	0	0	0	0
0	1	0	1	1
1	0	0	1	1
1	1	1	1	0

Symbol → && &

relational operator

bitwise operator

(To combine multiple conditions in if)

if (n%2 == 0 && n%3 == 0)
^{false dominant}

→ || ^{true dominant}
relational operator

→ bitwise operator

Possible

→ ^{binary no.} 26 ^{binary no.} 35 → ^{binary answer} ^{decimal} ans



Qui2:

② 23 | 10

Quiz:

⑫ 23^{10}

Quiz:

$20: \begin{matrix} 4 & 3 & 2 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 \end{matrix}$
 $15: \begin{matrix} 0 & 1 & 1 & 1 & 1 \\ \hline 1 & 1 & 0 & 1 & 1 \end{matrix} \Rightarrow 2^0 + 2^1 + 2^2 + 2^4 = 27$



Q) you have been given a positive no., identify whether the number is even or odd.

Ex: $N=8 \rightarrow \text{even}$

$N=7 \rightarrow \text{odd}$

Note: We of $+$, $-$, $*$, 1 or $\%$ is not allowed.

$N=10$: 1 0 1 0

+1

$N=11$: 1 0 1 1
+1
+ 0 0 0 1

$N=12$: 1 1 0 0
+1
+ 0 0 0 1

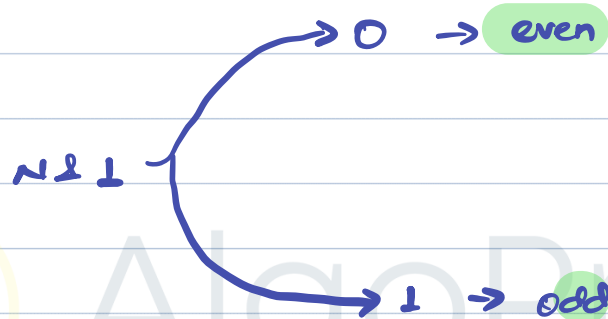
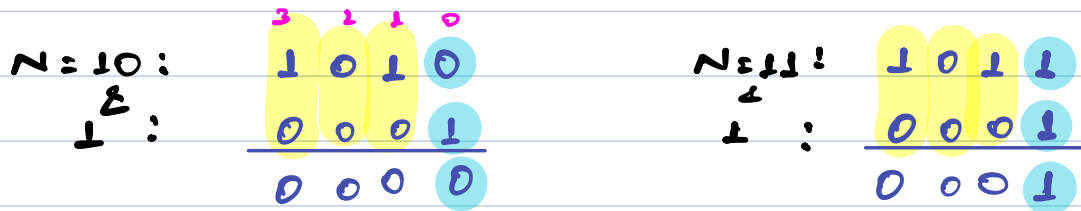
$N=13$: 1 1 0 1

Obs: (i) Rightmost bit for even no is always 0.

(ii) Rightmost bit for odd no is always 1.



→ To check last bit.



// Pseudo code

```
void checkeven (int n) {  
    if (n & 1 == 0) {  
        s.o.p ("even");  
    }  
    else {  
        s.o.p ("odd");  
    }  
}
```

Break till 9:36 Pm



// Properties

④ Commutative Property

$$a \oplus b = b \oplus a$$

$$a \mid b = b \mid a$$

$$a \wedge b = b \wedge a$$

⑤ Associative Property

$$a \oplus b \oplus c \rightarrow (a \oplus b) \oplus c = a \oplus (b \oplus c)$$

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

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

iii) a) $N \oplus N = N$

$$\begin{array}{r}
 N \rightarrow 110 \\
 N \rightarrow 110 \\
 \hline
 N \oplus N \rightarrow 110
 \end{array}$$

$$\begin{array}{r}
 N \rightarrow 110 \\
 0 \rightarrow 000 \\
 \hline
 N \oplus 0 \rightarrow 000
 \end{array}$$

b) $N \oplus 0 = 0$

$$\begin{array}{r}
 N \rightarrow 110 \\
 0 \rightarrow 000 \\
 \hline
 N \oplus 0 \rightarrow 110
 \end{array}$$

$$\begin{array}{r}
 N \rightarrow 110 \\
 N \rightarrow 110 \\
 \hline
 N \mid N \rightarrow 110
 \end{array}$$

c) $N \mid 0 = N$

$$\begin{array}{r}
 N \rightarrow 110 \\
 0 \rightarrow 000 \\
 \hline
 N \mid 0 \rightarrow 110
 \end{array}$$

$$\begin{array}{r}
 N \rightarrow 110 \\
 N \rightarrow 110 \\
 \hline
 N \wedge N \rightarrow 110
 \end{array}$$

d) $N \mid N = N$

$$N \rightarrow 110$$

$$N \rightarrow 110$$

e) $N \wedge 0 = 0$

$$\begin{array}{r}
 0 \rightarrow 000 \\
 N \wedge 0 \rightarrow 110
 \end{array}$$

$$\begin{array}{r}
 N \rightarrow 110 \\
 N \wedge N \rightarrow 000
 \end{array}$$

f) $N \wedge N = 0$



Q) Given $arr[n]$, every element appears twice except for one element which appears once, find that unique element.

Ex: $arr[7]: \{6, 8, 8, 7, 7, 10, 6\} \rightarrow 10$

$arr[5]: \{2, 1, 9, 2, 9\} \rightarrow 1$

// idea \rightarrow Take xor of the array

$arr[7]: \{6, 8, 8, 7, 7, 10, 6\}$

$\{6 \oplus 6 \oplus 7 \oplus 7 \oplus 8 \oplus 8 \oplus 10\} \rightarrow 10$

$arr[7]: \{6, 8, 8, 7, 7, 10, 6\}$

$8 \oplus 10 \oplus 8 = 10$

6: 0110

14: 1110

8: 1000

6: 0110

1110 = 14

1000 = 8

8: 1000

15: 1111

7: 0111

10: 1010

$8 \oplus 7 = 15$

0101 $\rightarrow 5$

5: 0101

2: 0010

7: 0111

8: 1000

0010 $\rightarrow 2$

1010 $\rightarrow 10$



```
int ans = 0;
```

T.C: $O(N)$

S.C: $O(1)$

```
for (int i = 0; i < N; i++) {  
    ans = ans ^ arr[i];  
}
```

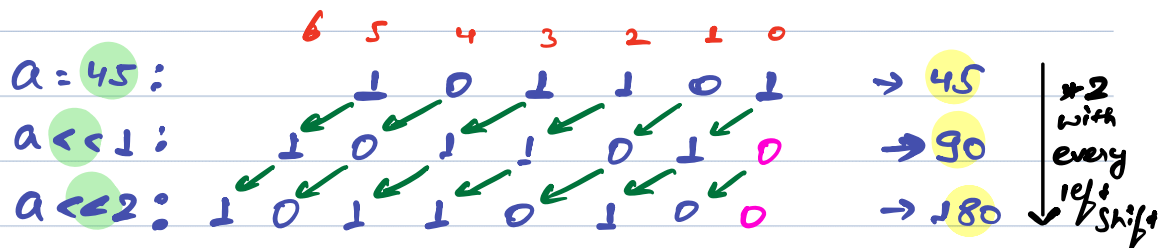
s.o.p (ans);



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↳ left shift (\ll)



$$a \ll n = a * 2^n$$

Qw2:

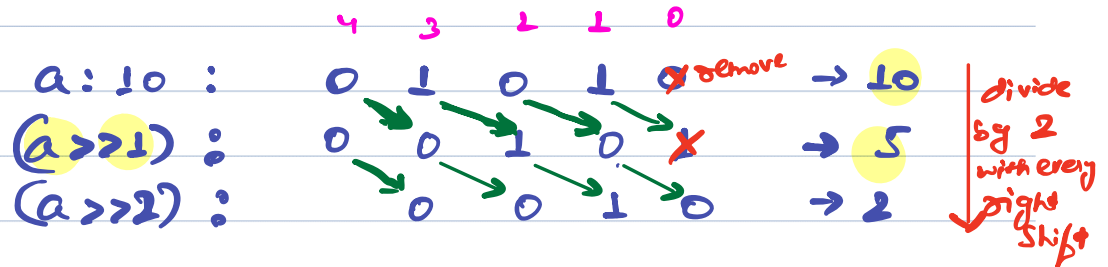
$a := 1$

$$1 \ll n \rightarrow 1 * 2^n = 2^n$$

↳ to calculate 2^n , use left shift operator as it is $O(1)$ complexity operation.



↳ right shift (\gg)



$$A \gg n = \frac{A}{2^n}$$



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Constraints

1 sec = 10^8 iterations

↳ array length = 10^5

↳ $O(N^2) \rightarrow (10^5)^2 = 10^{10}$ iterations

↳ $O(N\sqrt{N}) \rightarrow 10^5 * \sqrt{10^5} \Rightarrow 10^5 * 10^{2.5} = 10^{7.5}$



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