

Bit-Manipulation



video-6

Qns.

contest.

Leetcode
- 2939
Medium

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Maximum Xor Product

Company :- will update later...

2939. Maximum Xor Product

Hint

Medium

33

39



Companies

Given three integers a , b , and n , return the **maximum value** of $(a \text{ XOR } x) * (b \text{ XOR } x)$ where $0 \leq x < 2^n$.

Since the answer may be too large, return it **modulo** $10^9 + 7$.

Note that XOR is the bitwise XOR operation.

Example :- $a = 12, b = 5, n = 4$

Output :- 98 $\rightarrow (x = 2)$

$$\begin{array}{c} 14 \\ \hline (12 \wedge 2) \end{array} * \begin{array}{c} 7 \\ \hline (5 \wedge 2) \end{array} \quad 0 \leq x < 16$$

Some Facts...

1. Whenever Qns like these
 \rightarrow Max XOR, AND, OR etc.

"Solve bit by bit"

Find the answer bit by bit.

2. How to find i^{th} bit of a number?

$(num >> i) \& 1 = 1$

Example:-

4^{th}	3^{rd}	2^{nd}	1^{st}	0^{th}
0	0	0	0	0
0	0	0	0	0

$i = 3$

3. 2^x

✗

	2^3	2^2	2^1	2^0	
--- 0 0 0 0		0	0	0	$= 2^3 \leftarrow$
--- 0 0		0	0		$= 2^2$
--- 0					$= 2^1$

30

$2^{30} \Rightarrow 31 \text{ bits}$

4. $\eta \cup \eta \wedge x$

num = 0 1 0 1

$$x = \begin{array}{cccc} 0 & 1 & 1 & 1 \\ \hline 0 & 0 & 1 & 0 \end{array}$$

$$XOR = 0011$$

$$\begin{array}{cccc} 0 & 0 & 0 & 1 \\ \hline 0 & 0 & 1 & 0 \end{array}$$

$$XOR = 0$$

$$\begin{aligned} XOR &= (XOR \wedge (1 \ll 3)) \\ \Rightarrow XOR &= (XOR \wedge (1 \ll 2)) \end{aligned}$$

5. $1 \rightarrow 0$

$$25 - 2^4$$

$$25 - 16 =$$

$$\begin{array}{cccccc} 0 & 1 & 1 & 0 & 0 & 1 \\ \hline 0 & 0 & 1 & 0 & 0 & 1 \end{array} = 25$$

$$\begin{array}{cccccc} 0 & 0 & 1 & 0 & 0 & 1 \\ \hline 0 & 0 & 1 & 0 & 0 & 1 \end{array} = 9$$

$$\begin{array}{ccc} 1 & 1 & 1 \\ & \downarrow & \\ 1 & 0 & 1 \end{array} = 7$$

$$1 \quad 0 \quad 1 = 5$$



$$a = \underline{12}, \quad b = 14, \quad n = 4$$

$$0 \leq n \leq 50$$

x

$$a = \underline{1} \quad \underline{1} \quad \underline{0} \quad \underline{0}$$

$$x = \underline{0} \quad \underline{0} \quad \underline{?} \quad \underline{1}$$

$$\Rightarrow \underline{1} \quad \underline{1} \quad ? \quad \underline{1} \quad *$$

$(a \wedge x)$

$$b = \underline{1} \quad \underline{1} \quad \underline{1} \quad \underline{0}$$

$$x = \underline{0} \quad \underline{0} \quad \underline{?} \quad \underline{1}$$

$$\underline{1} \quad \underline{1} \quad ? \quad \underline{1}$$

$(b \wedge x)$

~~(A)~~

(i) if

$$\underline{i^{\text{th}} \text{ bit of } a} = \underline{i^{\text{th}} \text{ bit of } b}$$

$$\Rightarrow \underline{a \oplus x} = (a \oplus x \wedge (1 \ll i));$$

$$\underline{b_{xor} = (b_{xor} \wedge (1 \ll i));}$$

When, i^{th} bit of $a \neq i^{\text{th}}$ bit of b 

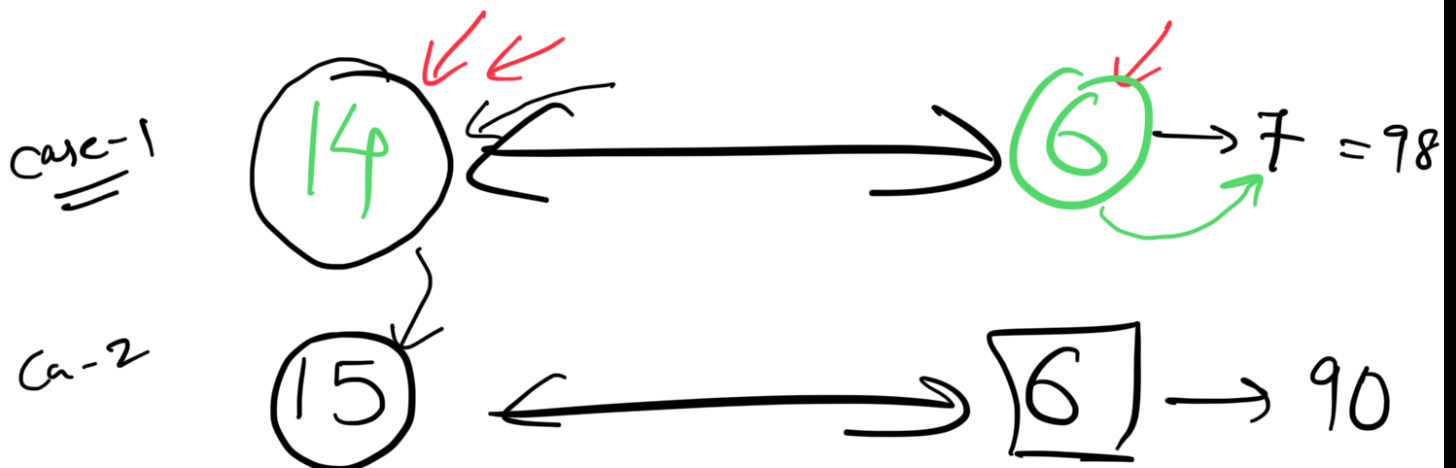
$$a = 12, \quad b = 5, \quad n = 4$$

$$a = \begin{pmatrix} 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{pmatrix}$$

$$b = \underline{0} \ \underline{1} \ \underline{0} \ \underline{1}$$

$$x = \underline{0} \underline{0} \underline{1} \underline{?}$$

$a_{1x} = \begin{pmatrix} 1 & 1 & 1 & ? \end{pmatrix} * b_{1x} = \begin{pmatrix} 0 & 1 & 1 & ? \end{pmatrix}$



$$15 * 6 = 90$$

$$\textcircled{14} * \textcircled{7} = 98$$

~~(B) for i if $(aXorX > \underline{bXorX})$ {
 $bXorX = (bXorX \wedge (1 \ll i));$
 } else {
 $aXorX = (aXorX \wedge (1 \ll i));$
 }~~

Constraints :-

- $$0 \leq a, b < 2^{50}$$

- $$0 \leq n \leq 50$$

$$0 \leq x < 2^{50}$$

$$\text{num} < 2^{50}$$

49

...

3

2

1

0

a, b

$$a = \boxed{1 \ 0 \ 0 \ 1 \ 0 \ 1}$$

$$x = \begin{array}{cccccc} 0 & 0 & 0 & 0 & 0 & 0 \\ \leftarrow & & & & & \\ & n+2 & n+1 & n & & \end{array}$$

$$a \wedge x = \boxed{1 \ 0 \ 0 \ 1 \ 0 \ 1} \quad \begin{array}{cc} (n-1) & \\ ? & ? \end{array}$$

$$n = 2$$

$$\Rightarrow 0 \leq x < 2^n$$

$$a \oplus a = 0$$

$$b \oplus b = 0$$

① 4^{th} bit $\rightarrow n^{th}$ bit

$$a \rightarrow a \oplus x$$

$$b \rightarrow b \oplus x$$

② $(n-1)^{th}$ bit $\rightarrow 0^{th}$ bit

