Fast Exponentiation

1) normal solutions to find $a^b \rightarrow O(b)$

$2^{10} \Rightarrow [\underbrace{2*2*2.....*2}_{10}]$

Loop $\rightarrow$ [0 $\rightarrow$ b-1] [ans = 1]

↳ ans = ans * a ;

Why learn this? $\rightarrow$ to get fast soln so that TLE ✗

2) Better soln $a^b \rightarrow O(\log b)$

$a^b \rightarrow$ if b $\rightarrow$ even

↳ $a^b \Rightarrow (a^{b/2})^2$

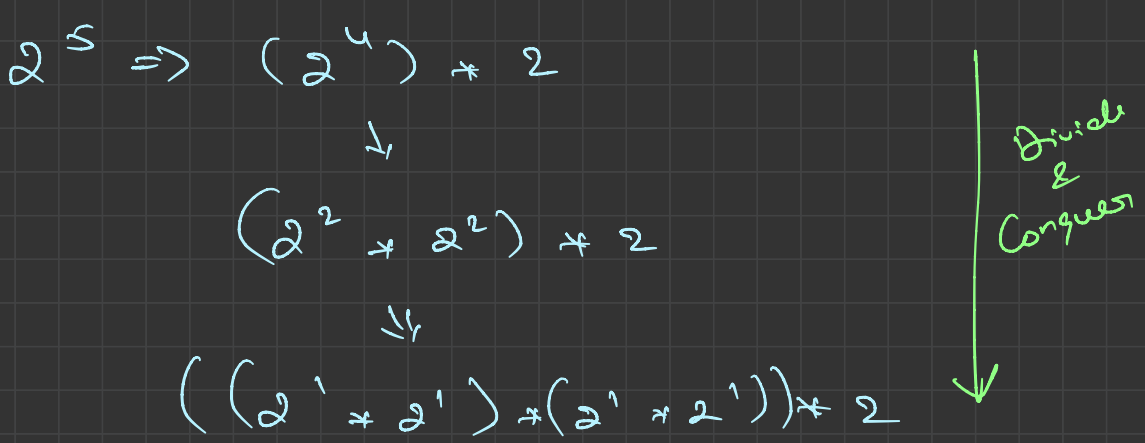
↳ if b $\rightarrow$ odd

↳ $a^b \Rightarrow (a^{b/2})^2 * a$

for ex

$2^{10} \Rightarrow$ Even $\rightarrow (2^{10/2})^2 = (2^5)^2 = 2^{10}$

$2^{11} \Rightarrow$ odd $\Rightarrow (2^5)^2 * 2$




```
class Solution {
public:
    int myPow(int a, int b) {
        int ans = 1;
        while(b > 0){
            if(b & 1){
                // odd
                ans = ans * a;
            }
            a = a * a;
            b >> b >> 1; // b = b / 2;
        }
        return ans;
    }
};
```

Dry Run

ans = 1

a = 5, b = 4

b = 4

b => even => a = a * a = 5 * 5 => 25

b = b >> 1 // b = b/2

a ↑

b = 2

b => even => a = a * a = 25 * 25 => 625

a ↑

b = 1

b => odd => ans = ans * a => 1 * 625

=> 625 (ans)

$5^4 \rightarrow 5^2 \cdot 5^2$

$5 * 5$ $\quad$ $5 * 5$

$25 * 25 = 625$

Dry Run

ans = 1 ✗ 2 ✗ 32
a = 2 ✗ 4 ✗ 16
b = 5

b = 5

b = odd ⇒ ans = ans * a ⇒ 1 * 2 ⇒ ans = 2

a = a * a ⇒ 2 * 2 ⇒ a = 4
(2 . 2)

b = 2

b = even ⇒ a = a * a ⇒ 4 * 4 ⇒ a = 16
(2² . 2²)

b = 1

b = odd ⇒ ans = ans * a ⇒ 2 * 16 ⇒ ans = 32
(2² . 2²) . 2

a = a * a ⇒ 16 * 16 ⇒ 256

b = 0 ⇒ return
↓
ans ⇒ 32

$2^5 \Rightarrow (2^2 \cdot 2^2) \cdot 2$

$((2 \cdot 2) \cdot (2 \cdot 2)) \cdot 2$