Introduction to Programming

Week – *11*, Lecture – *1*

Assorted Topics in C – Part 1

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IIT KANPUR

Recap – Boolean Algebra

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- The *NOT* function is defined over one Boolean variable as
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- For an expression, `e`, (`!e`) is `0`, if and only if, it evaluates to a non-zero value…
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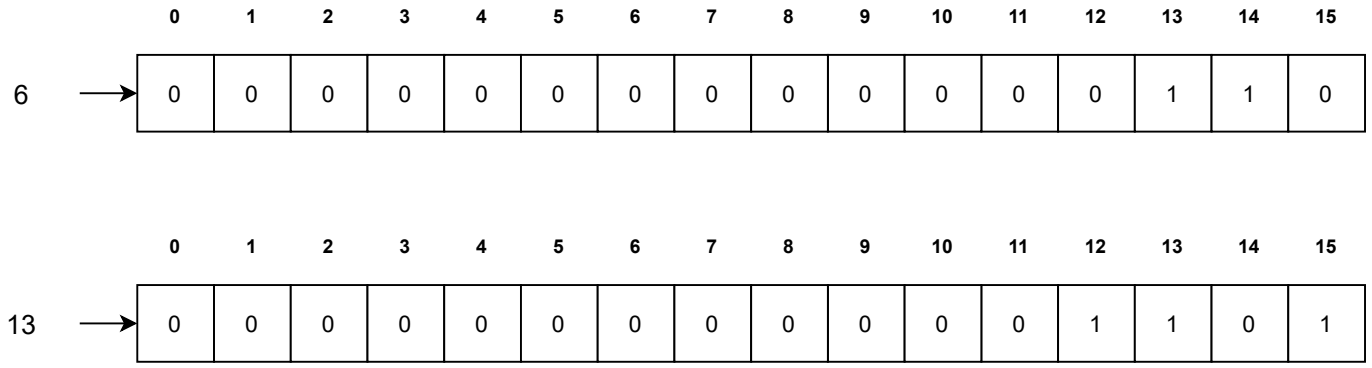
- XOR stands for *Exclusive OR*, which outputs a 1, if either of the two inputs (but not both) is `1`

Bitwise Representation of integers



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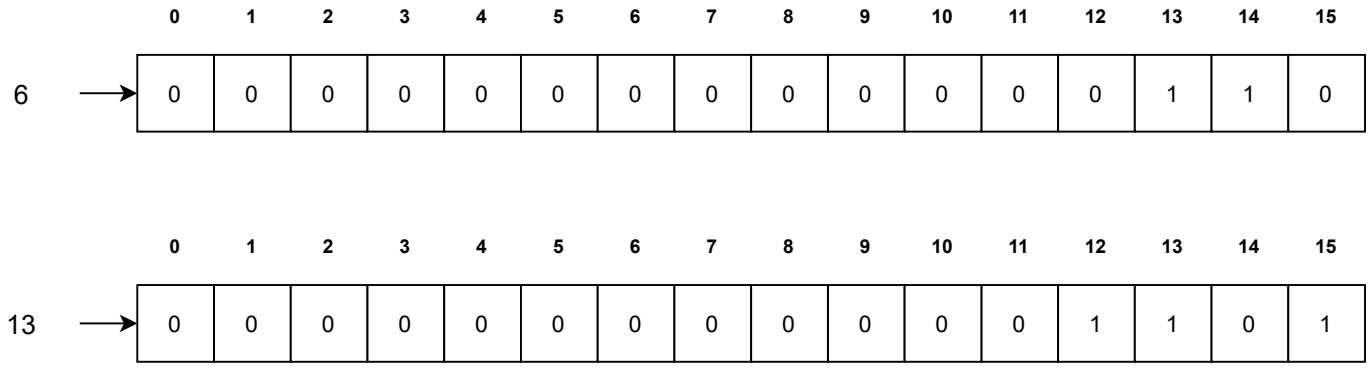

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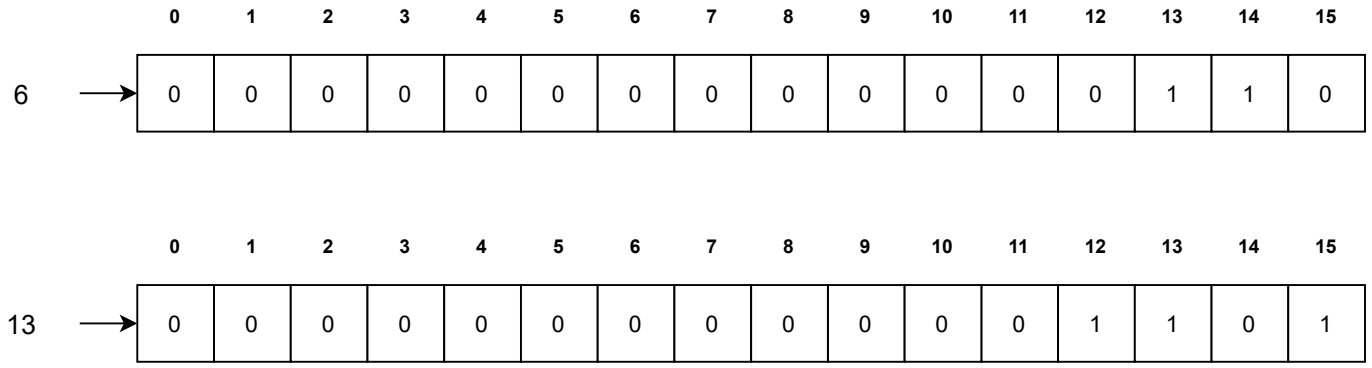

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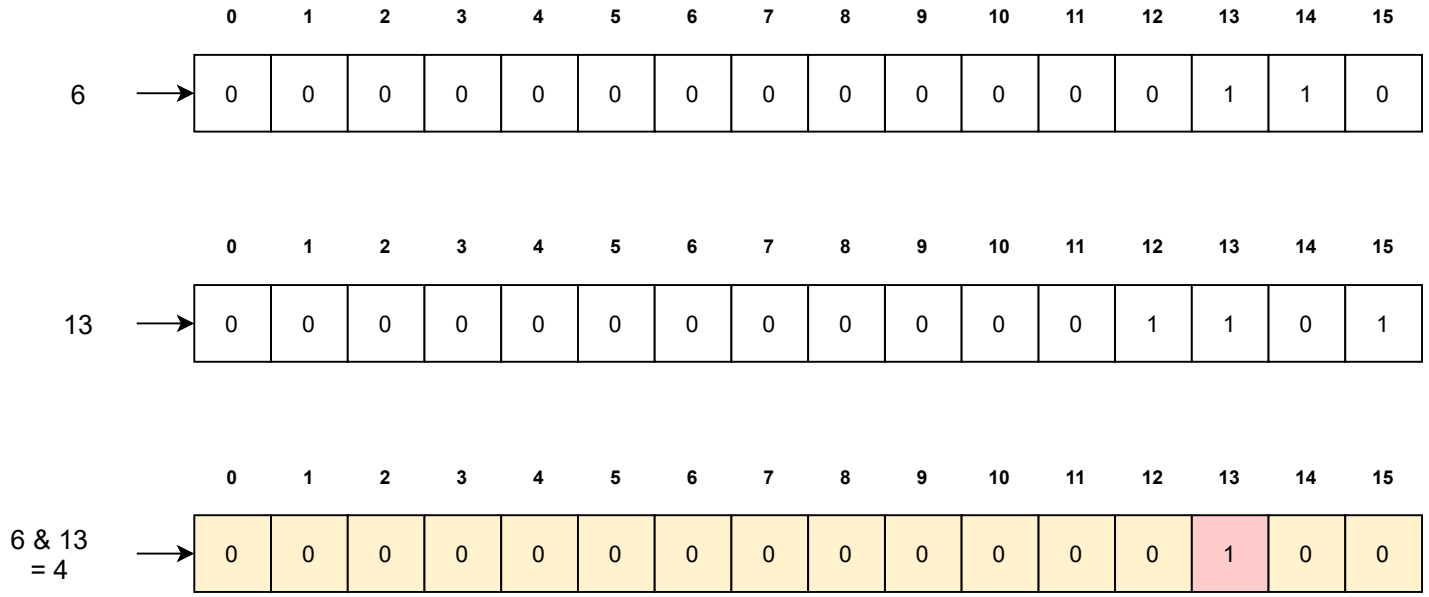
If the integers are unsigned, this is simply their representation

Bitwise AND Operator



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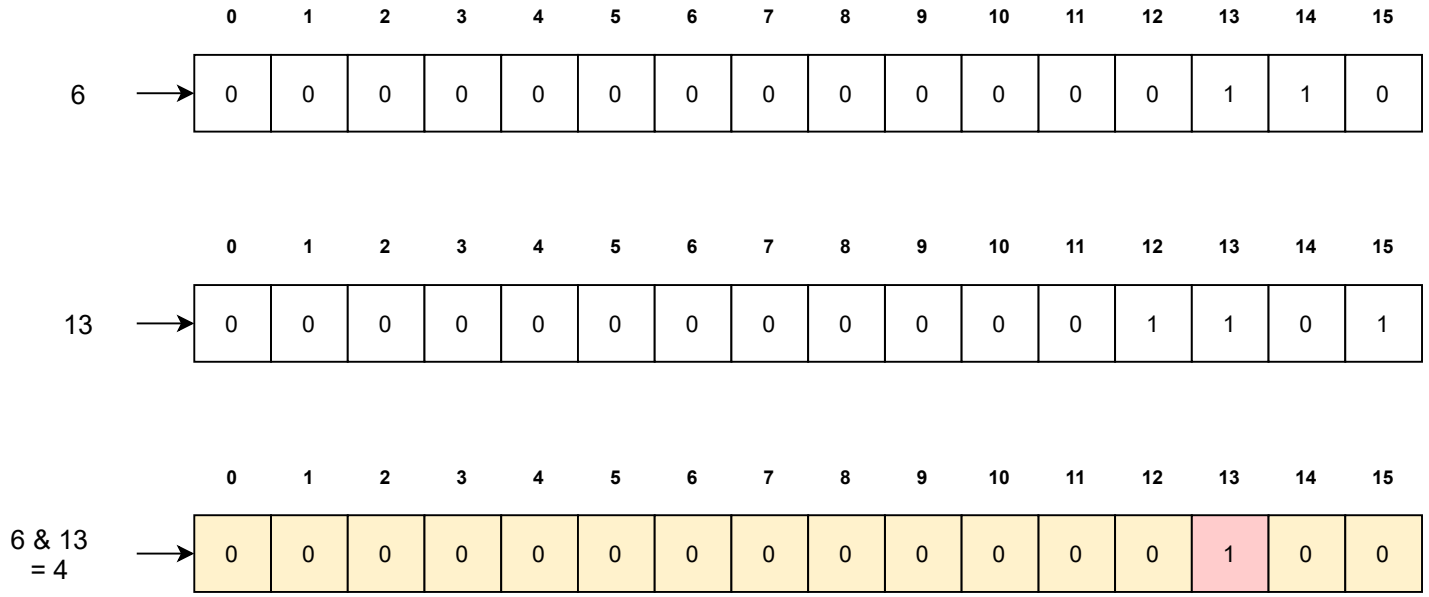

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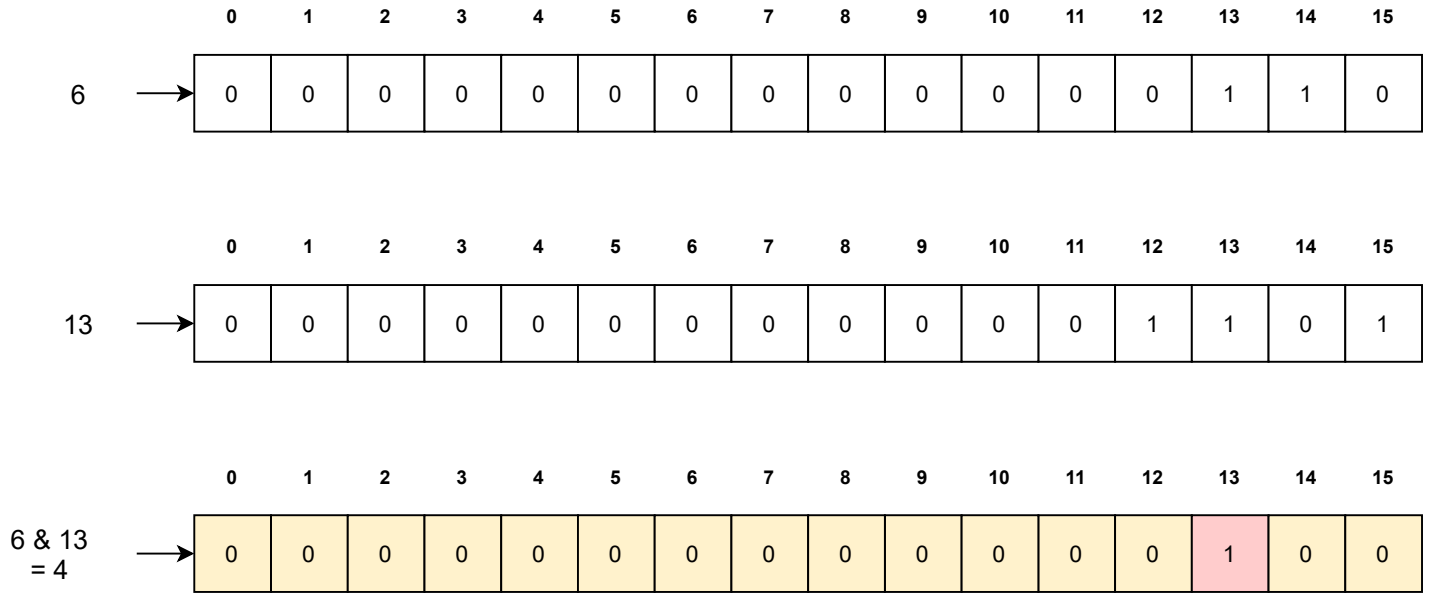

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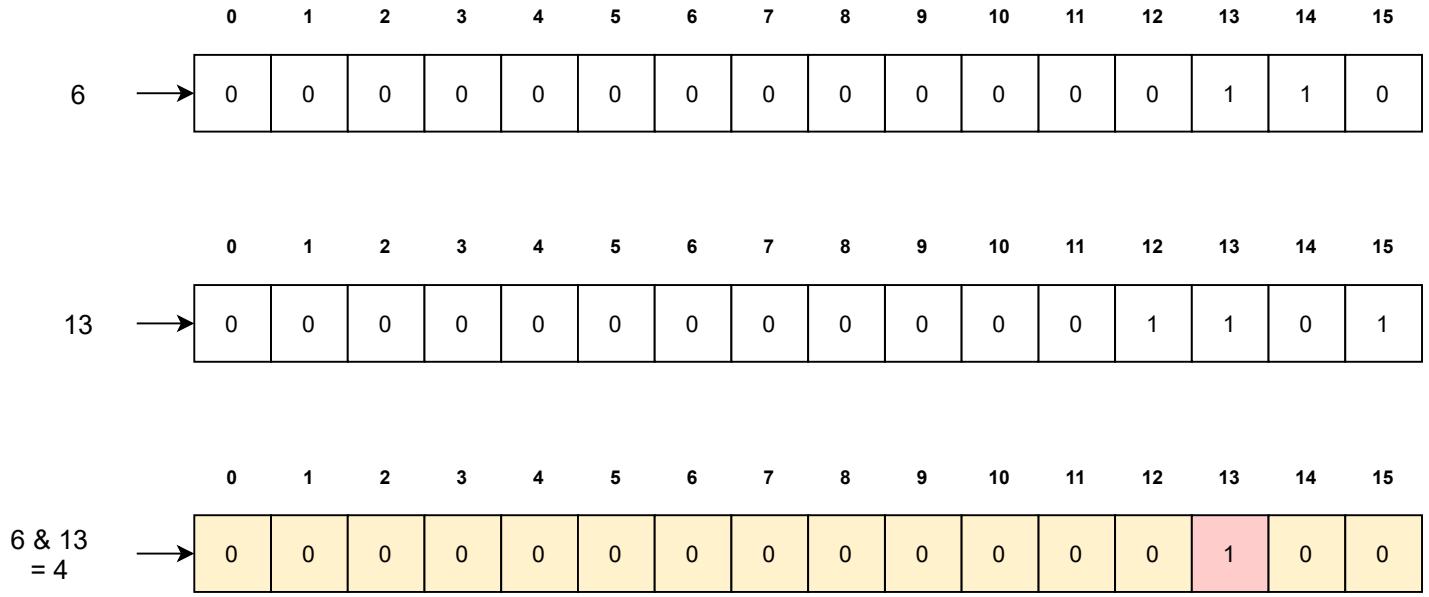

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The output too, is an integer in 16 bits

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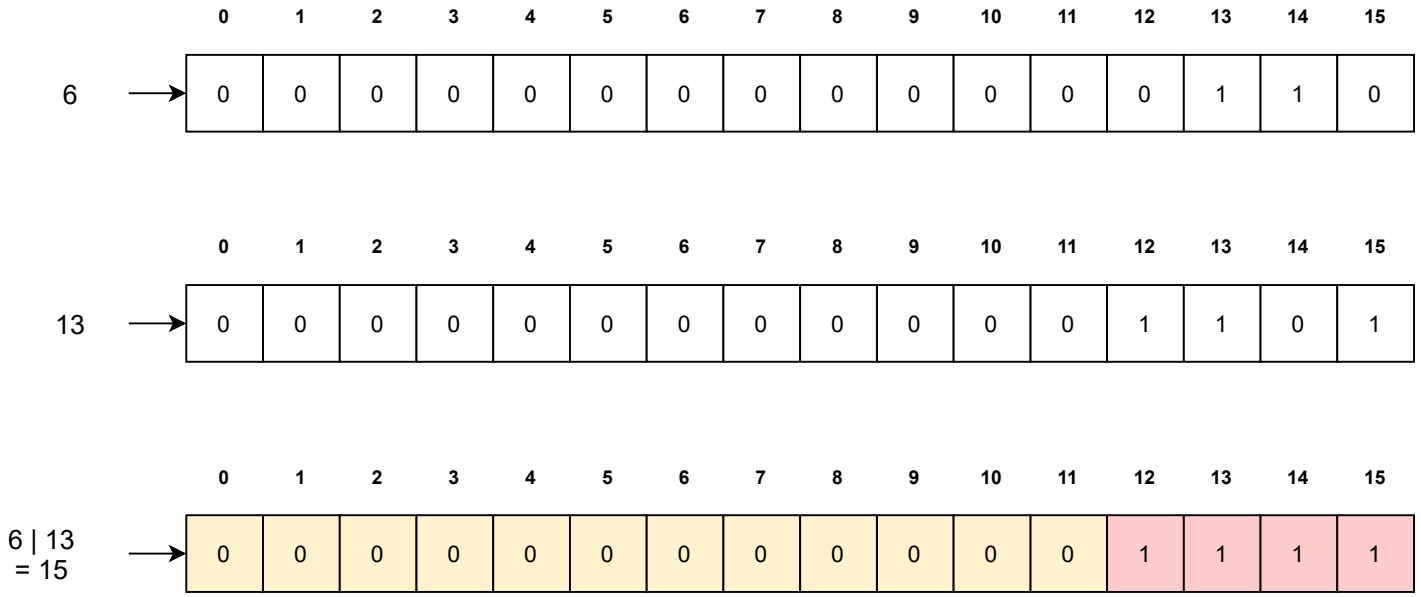

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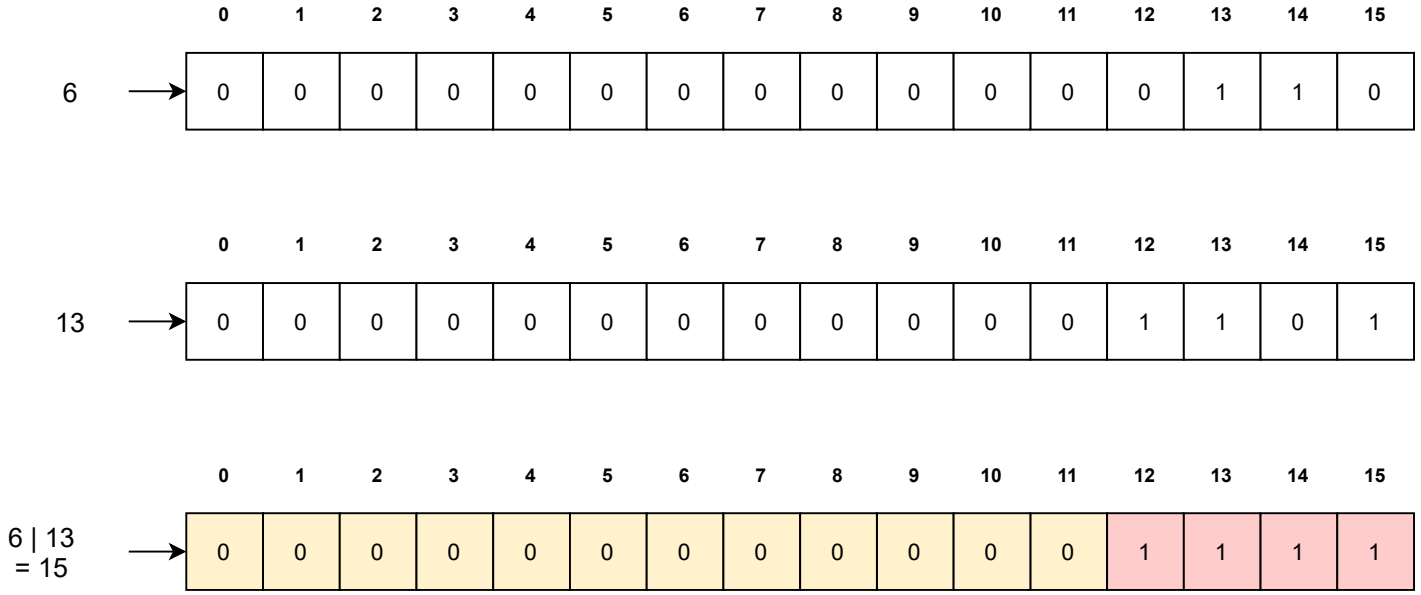

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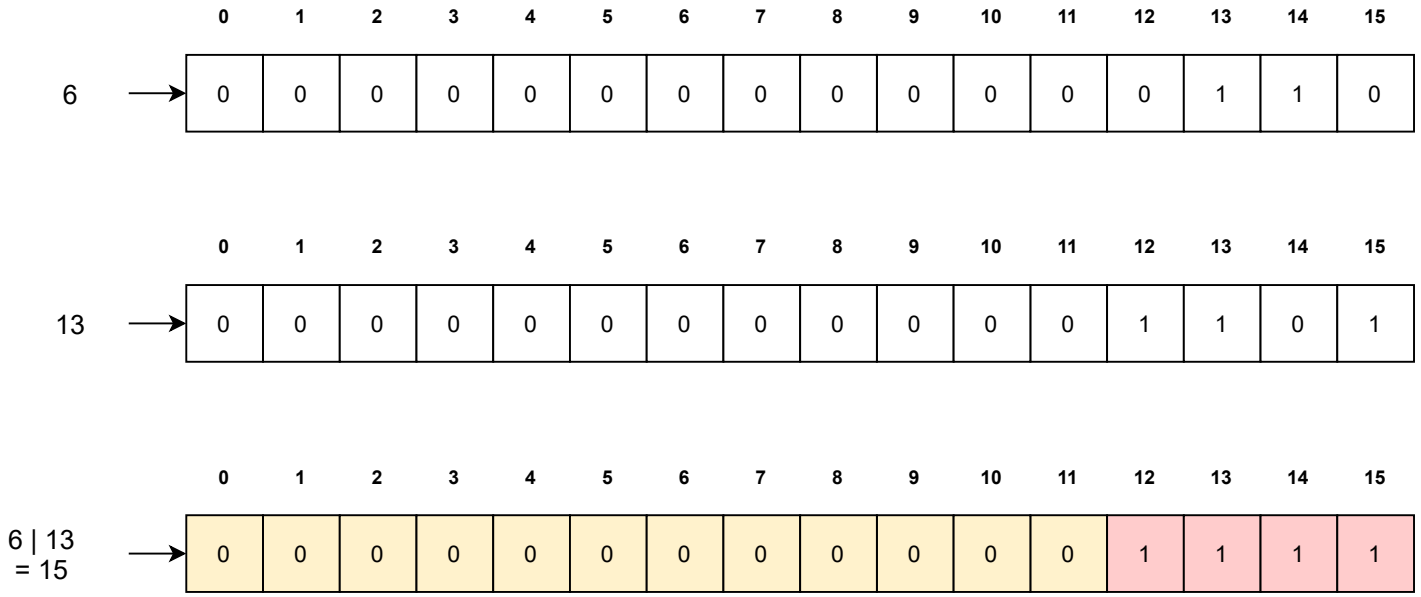

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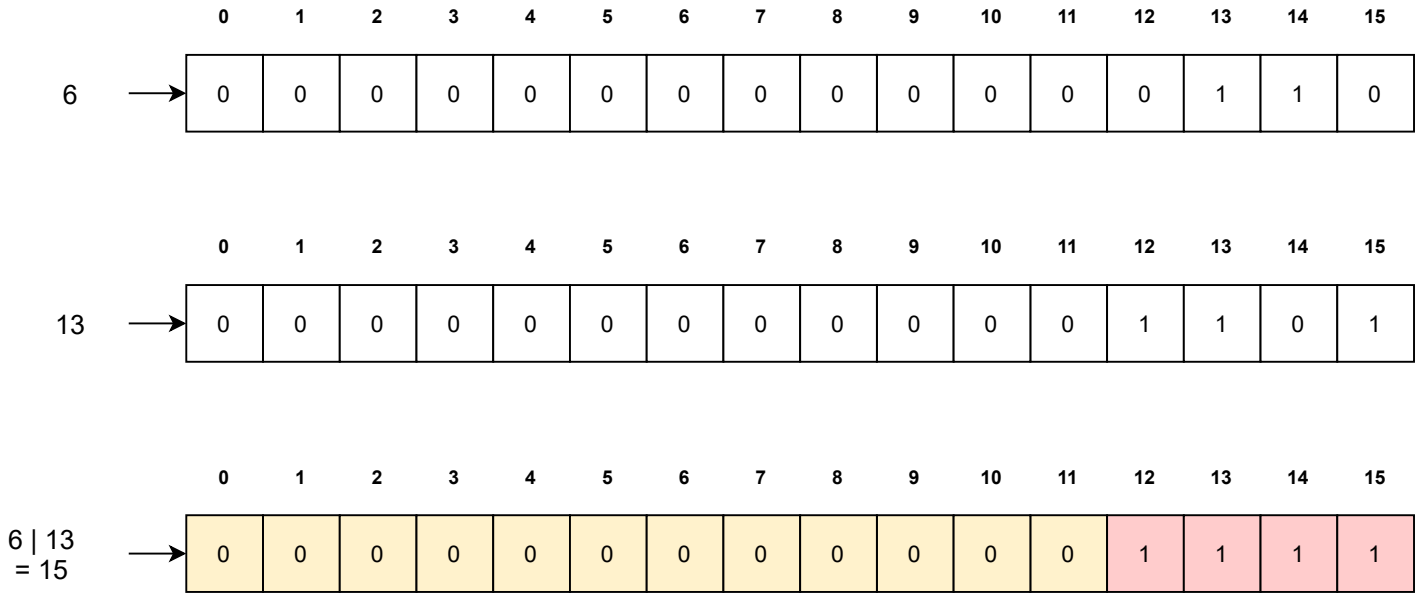

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Again, the output can be interpreted as an integer as well

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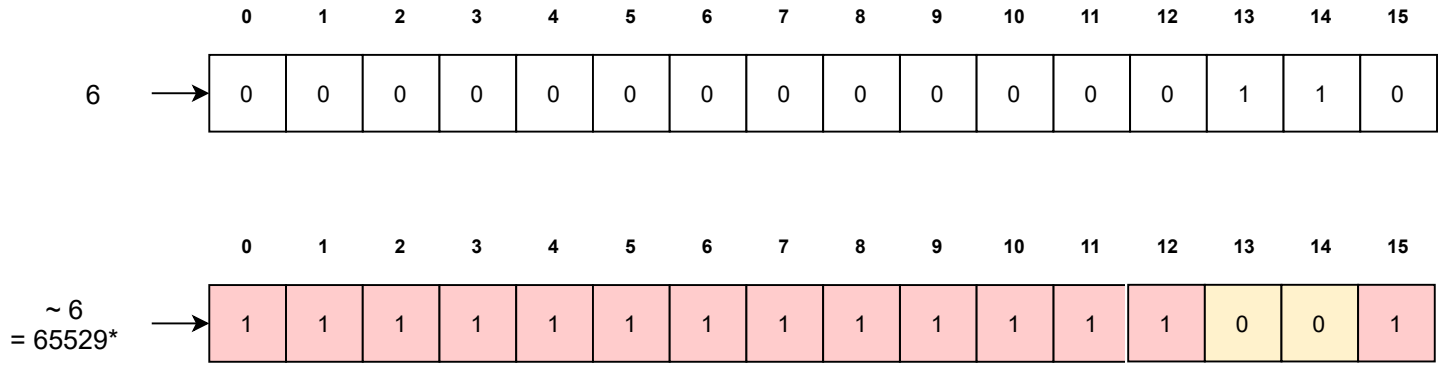

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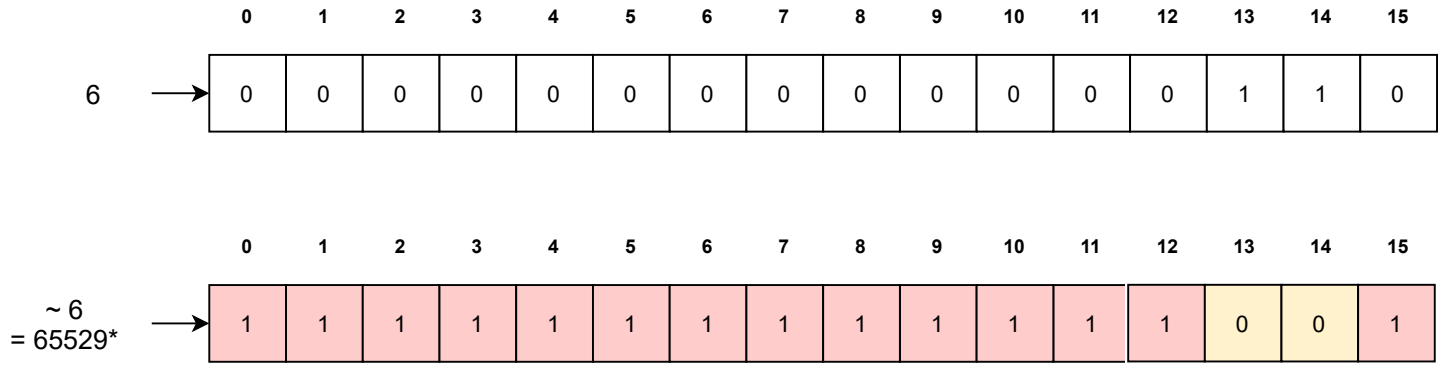

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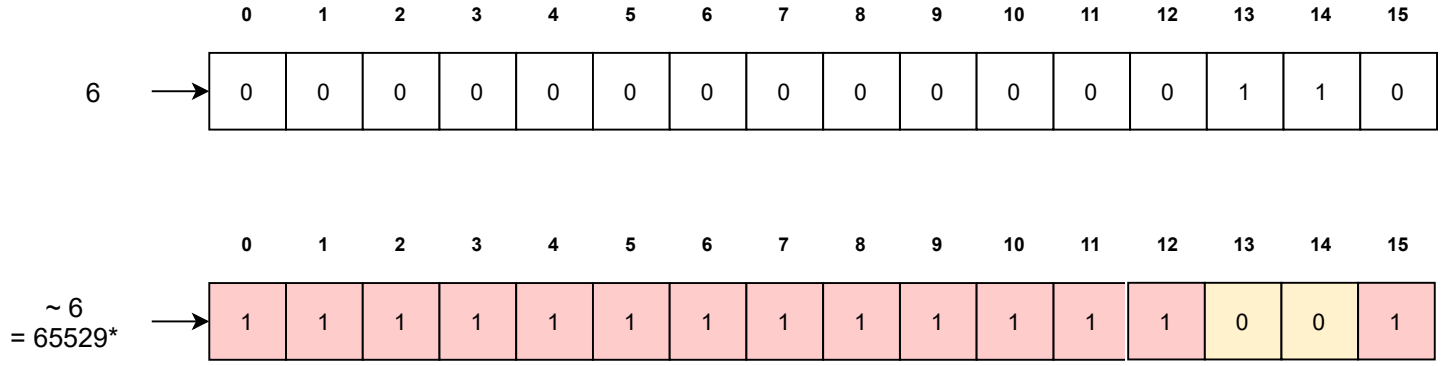

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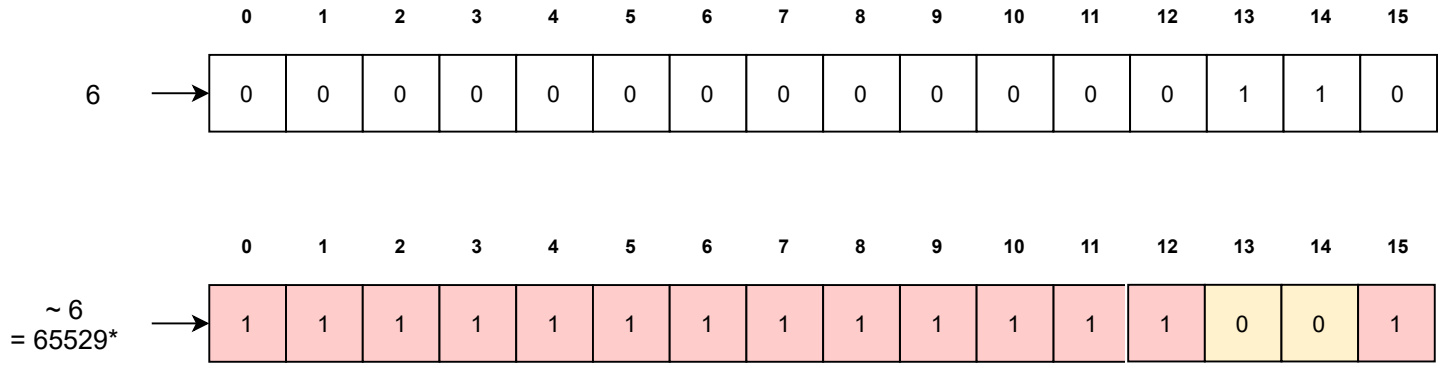

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Based on the representation, the sign might also be flipped (from + to − and vice versa)

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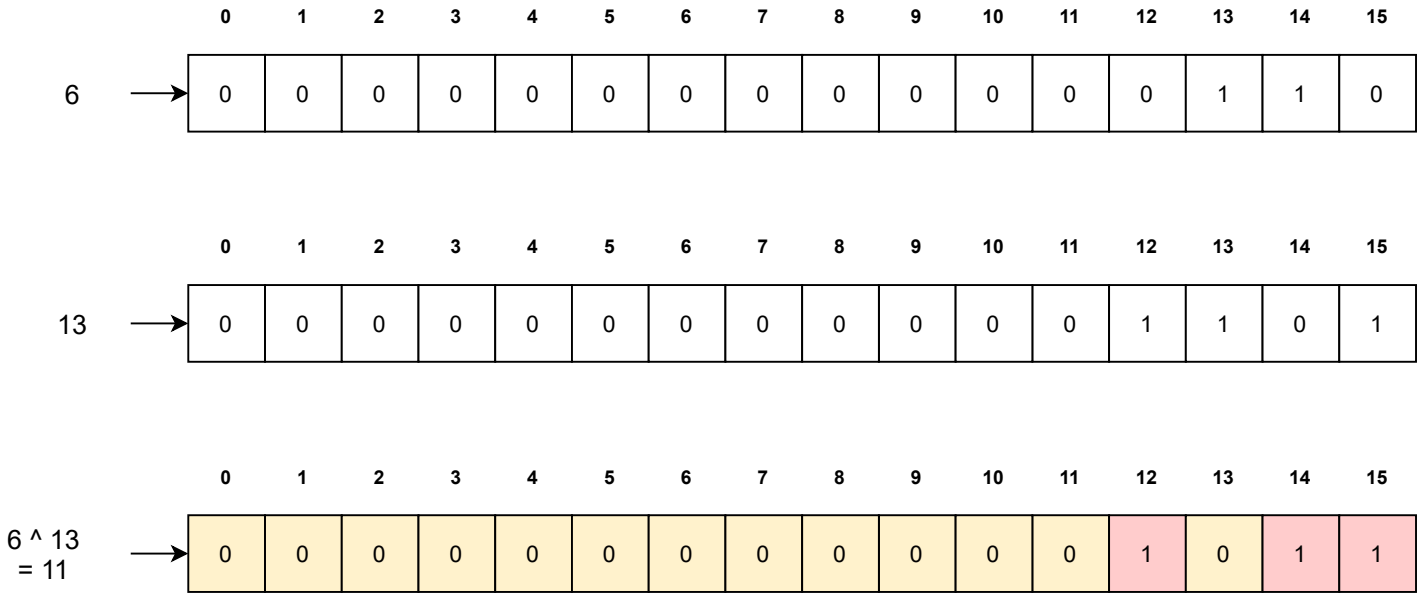

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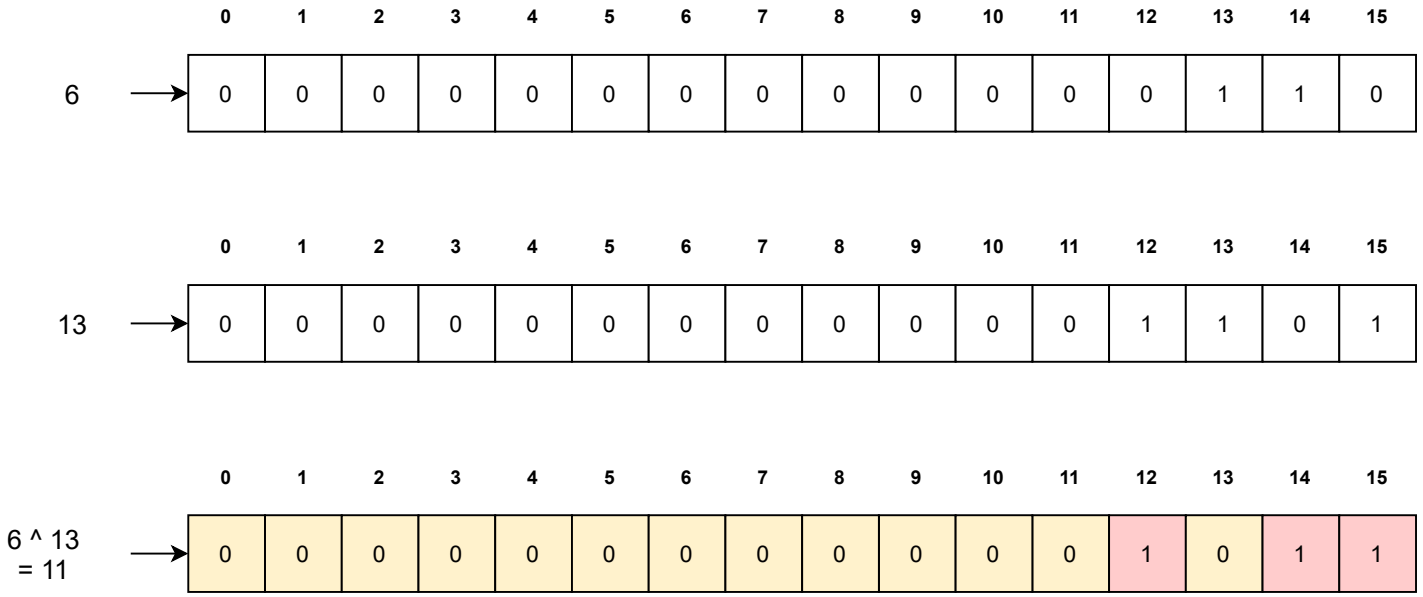

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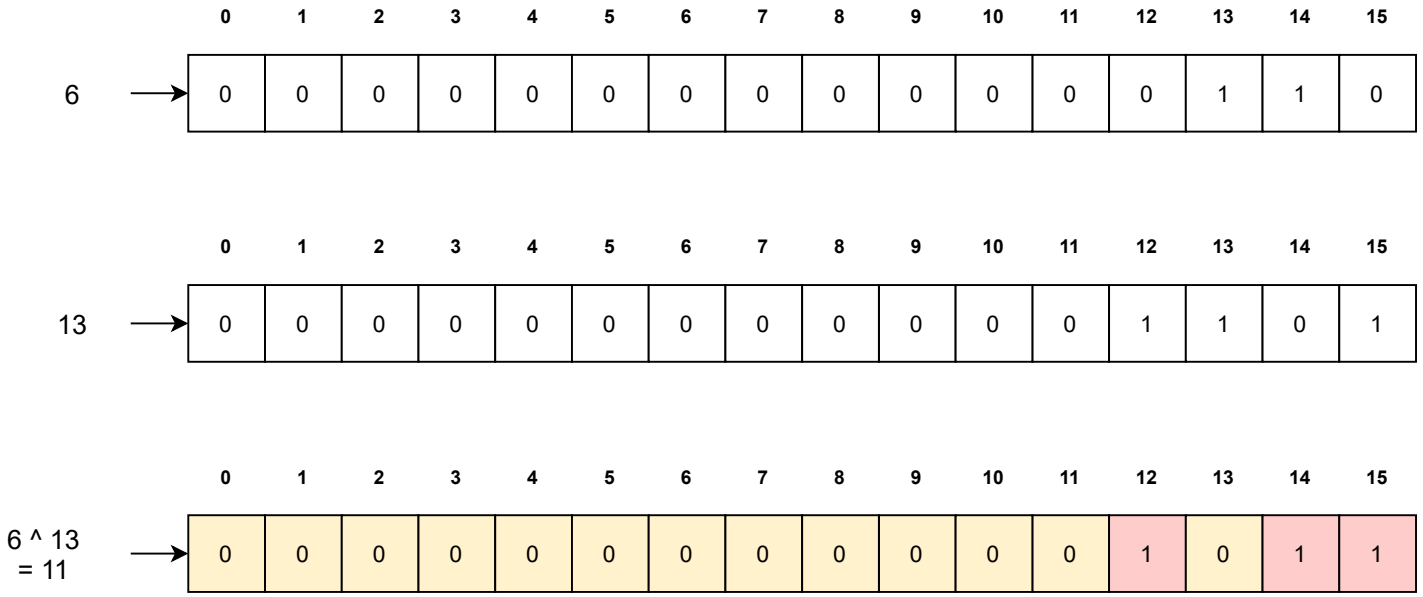

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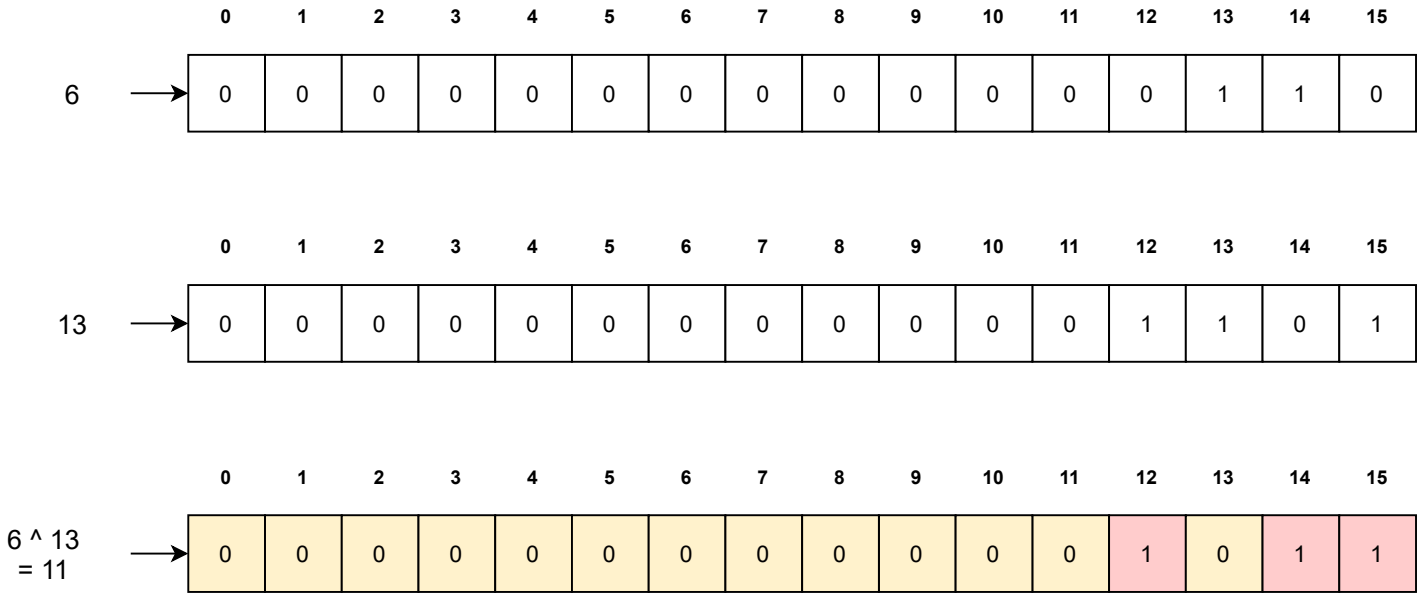

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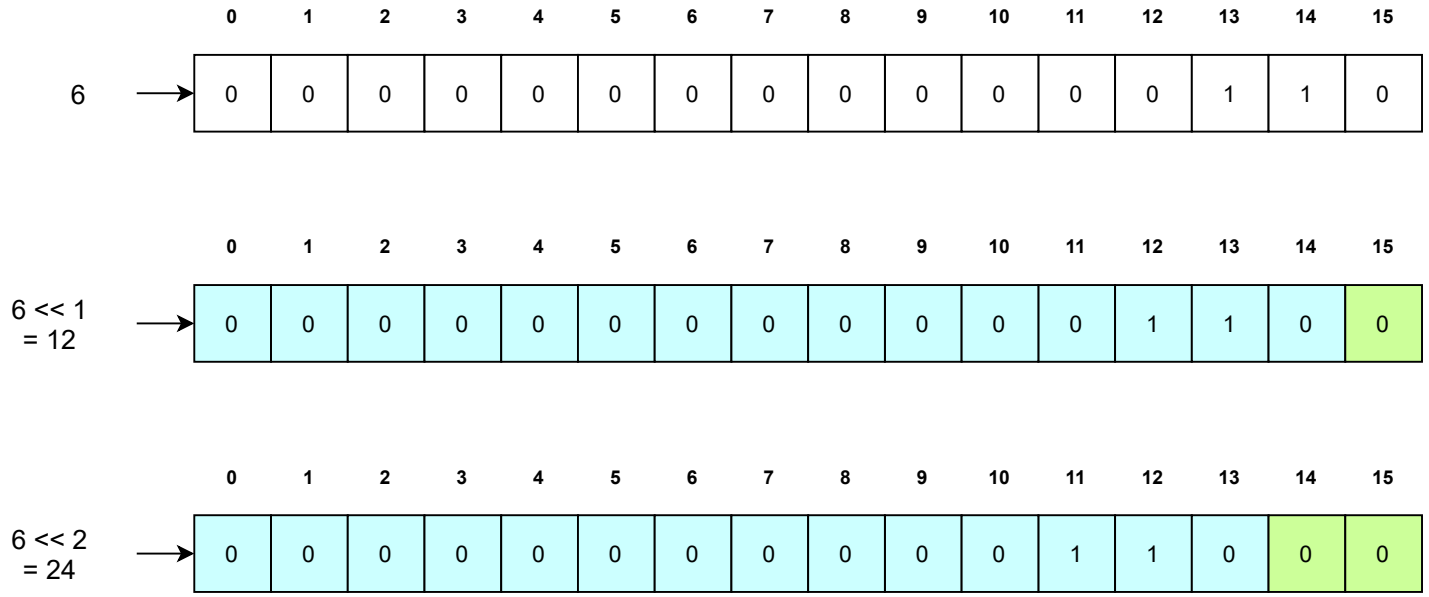
Left Shift Operator



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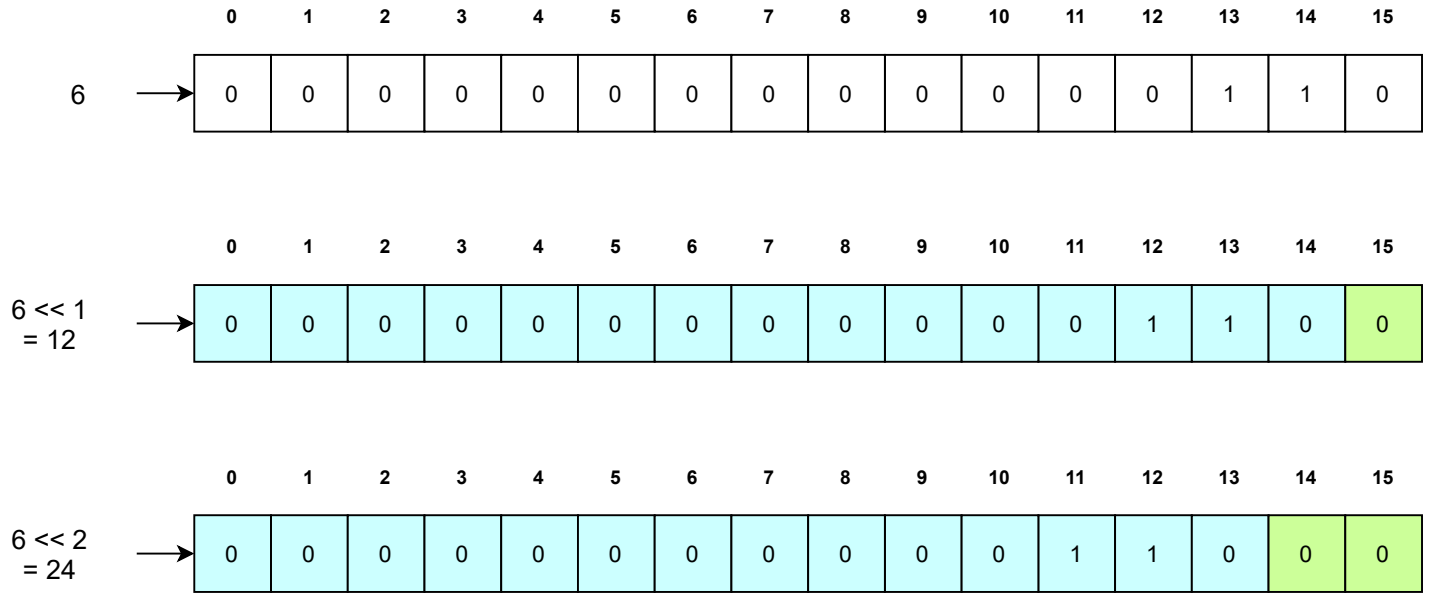

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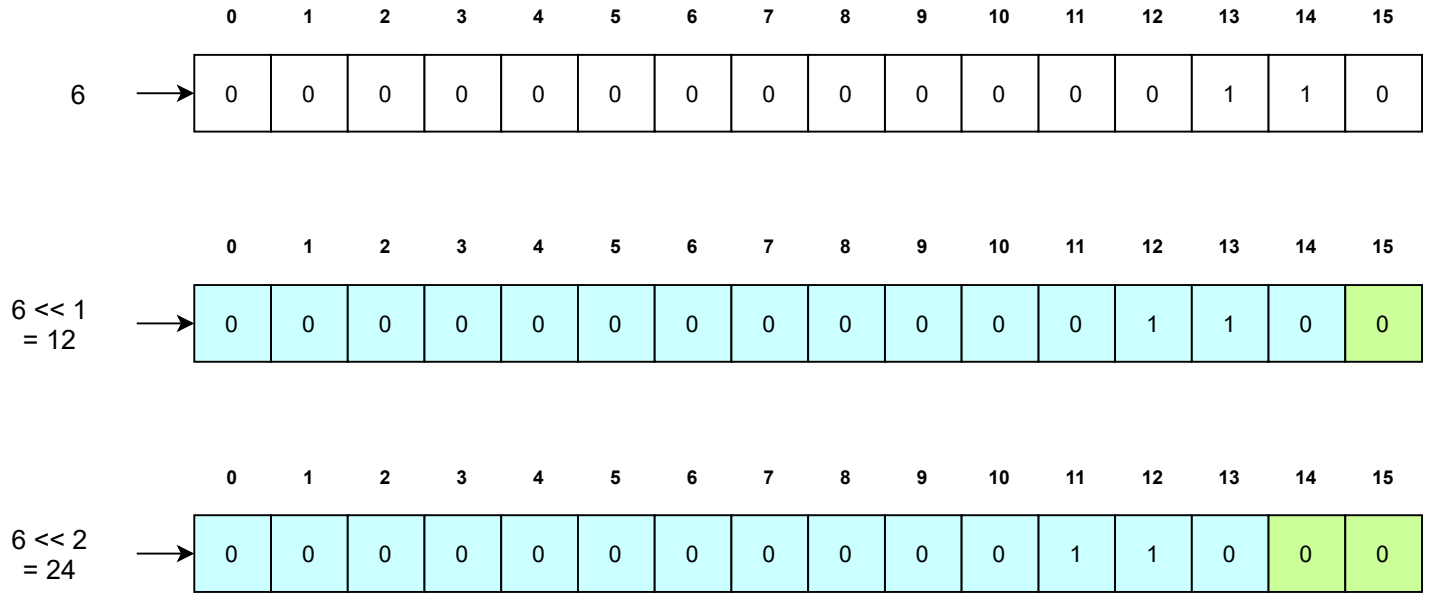

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Since the leftmost bit will be removed, interpretation is representation-specific

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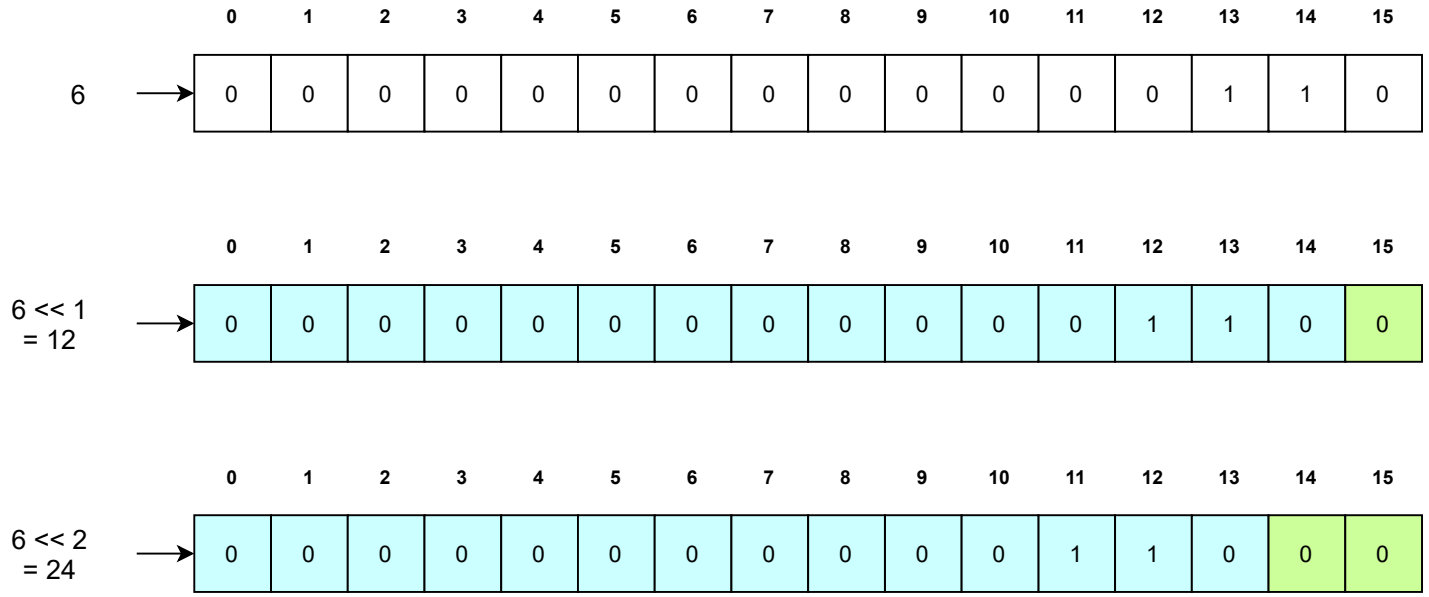

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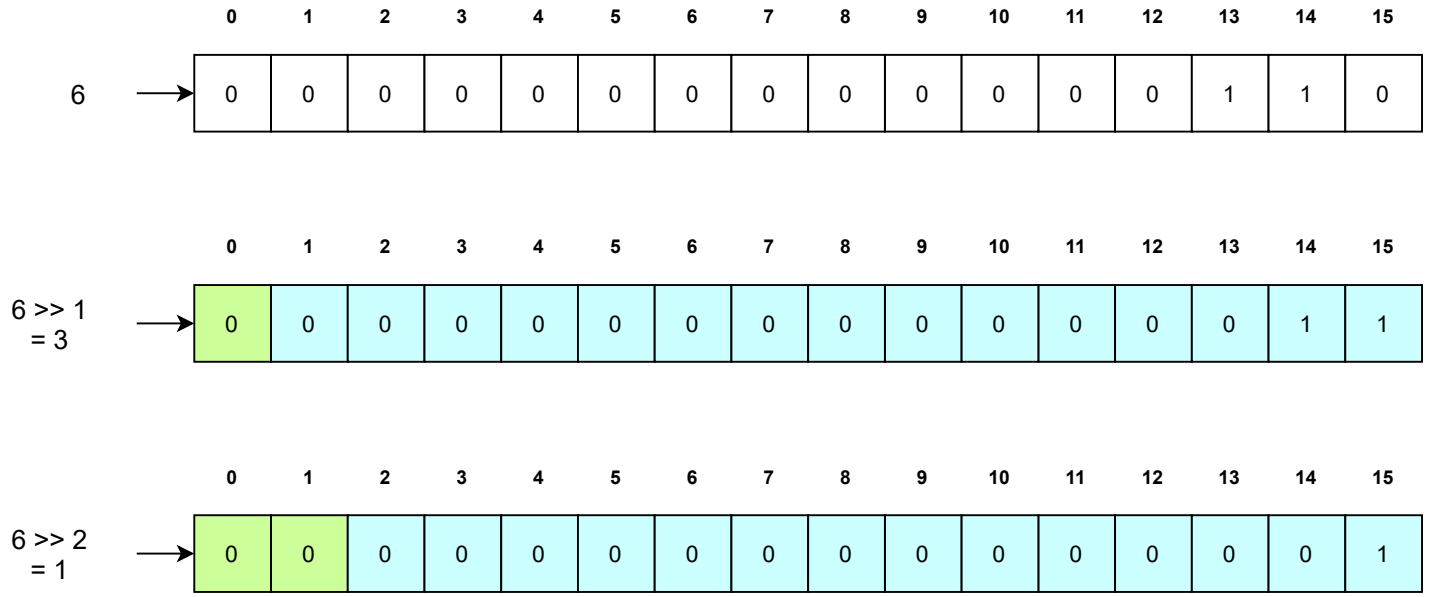
A left shift by k positions of an integer means its multiplication with 2^k

Since the leftmost bit will be removed, interpretation is representation-specific

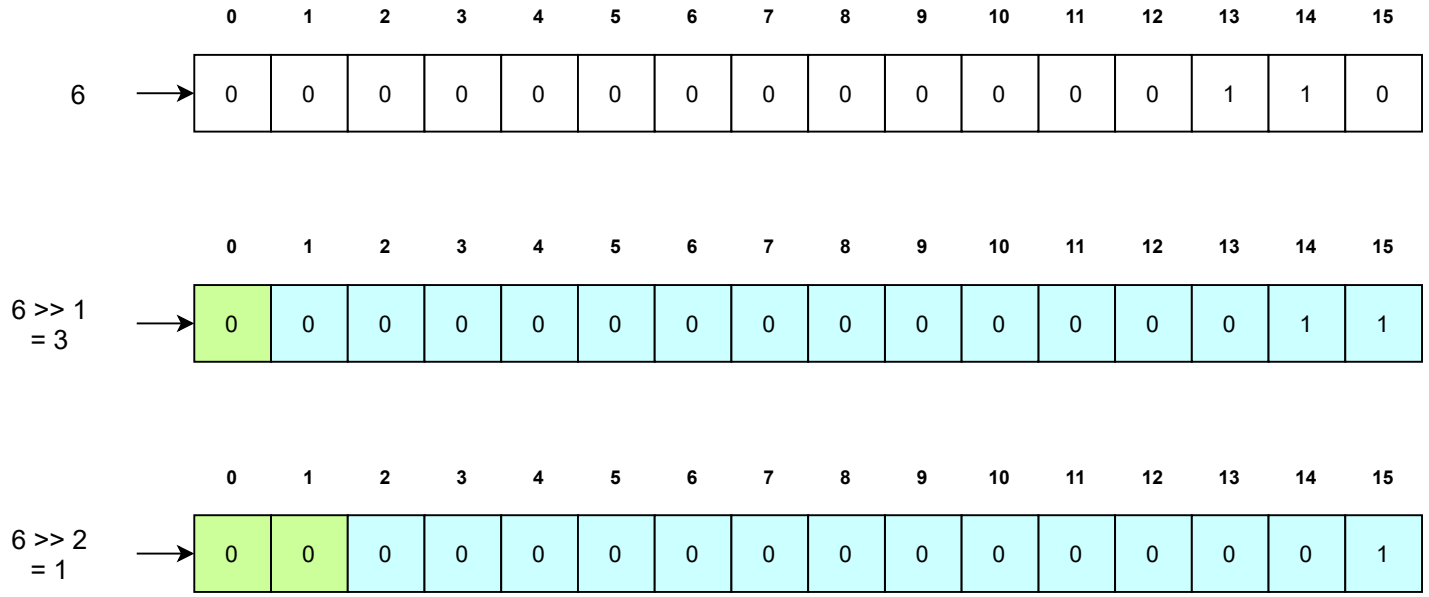
Based on the representation, the sign might also be flipped (from $+$ to $-$)

Right Shift Operator



The >> operator removes bits from the right and adds 0s from the right

Right Shift Operator



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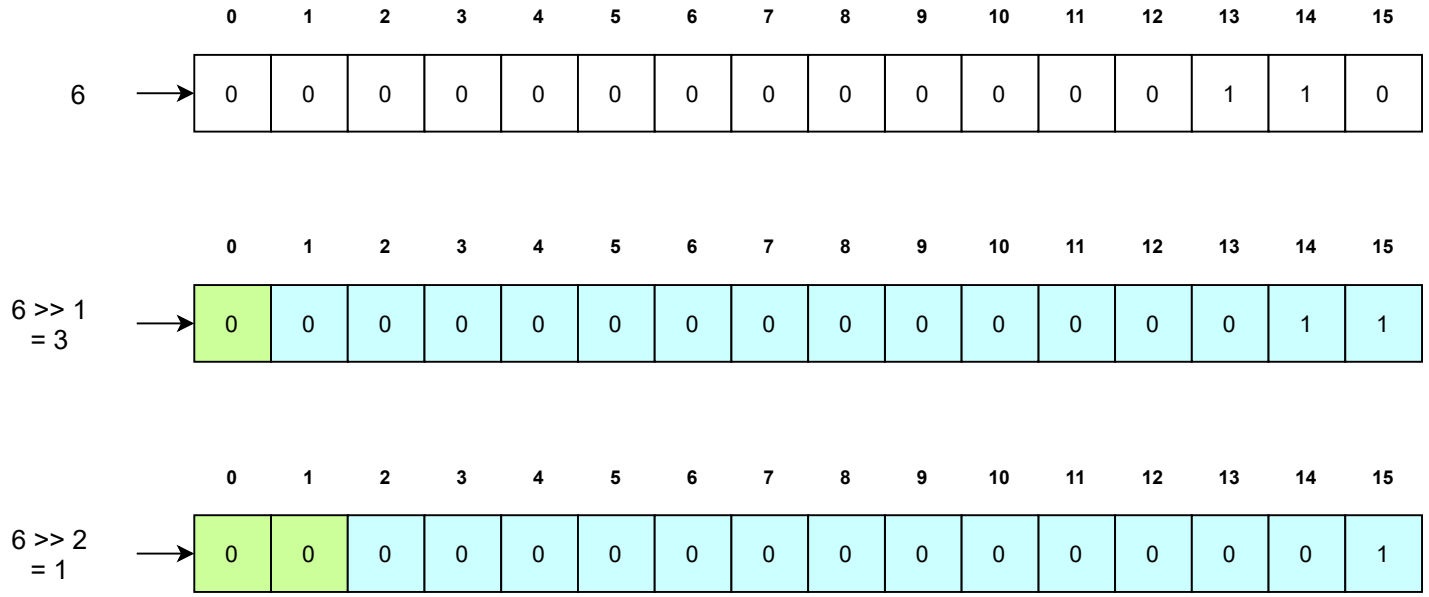

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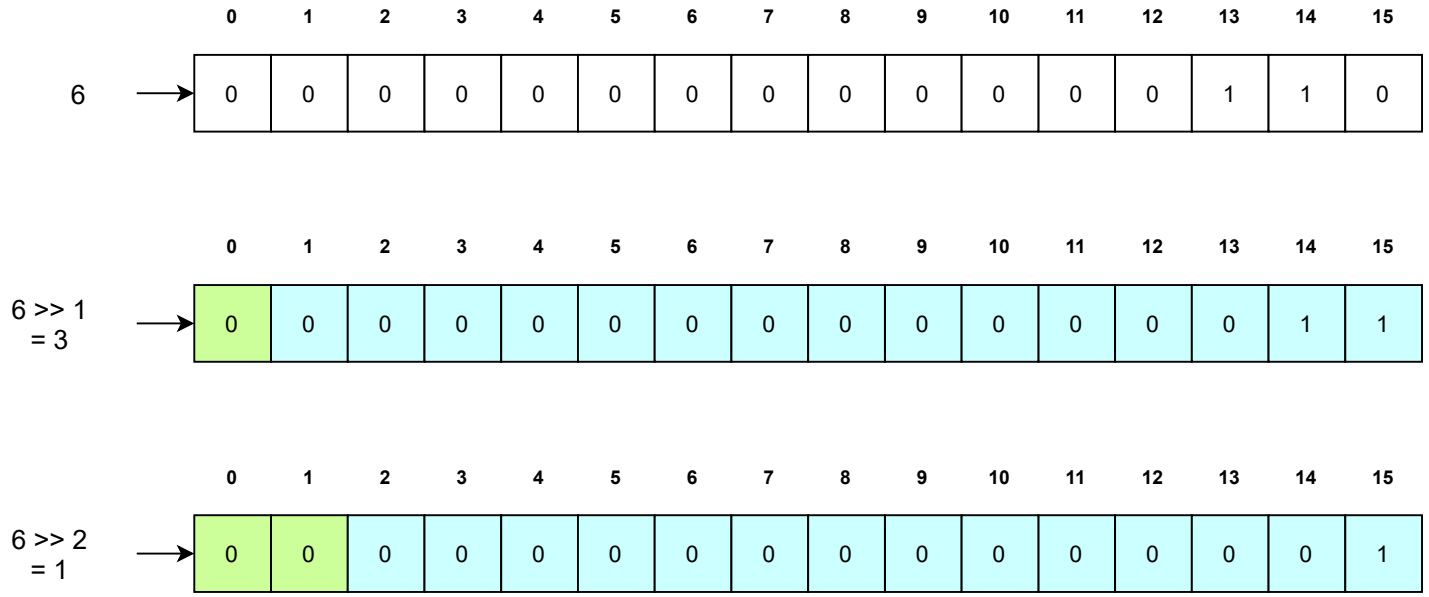

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The customary example

```c
#include<stdio.h>

int main()
{
        unsigned short op1 = 6;
        unsigned short op2 = 13;

        printf("This is a simple demonstration of bitwise operators\n");

        printf("%hu&%hu = %hu\n", op1, op2, op1&op2);
        printf("%hu|%hu = %hu\n", op1, op2, op1|op2);
        printf("~%hu = %hu in unsigned form\n", op1, ~op1);
        printf("~%hu = %hi in signed 2's complement form\n", op1, ~op1);
        printf("%hu<<1 = %hu\n", op1, op1<<1);
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Just the code to reproduce the examples in the slide

The customary example

```
saurabh@saurabh-VirtualBox:~/C/examples/Week 11$ gcc TheBitwiseWorld.c
saurabh@saurabh-VirtualBox:~/C/examples/Week 11$ ./a.out
This is a simple demonstration of bitwise operators
6&13 = 4
6|13 = 15
~6 = 65529 in unsigned form
~6 = -7 in signed 2's complement form
6<<1 = 12
6<<2 = 24
6>>1 = 3
6>>2 = 1
saurabh@saurabh-VirtualBox:~/C/examples/Week 11$
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A confirmation of the results that we saw in the slides

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The bitwise operators are applicable to integer types only…

- … i.e. `char`, `short`, `int` and `long`

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- If a particular computation can be formulated in terms of bitwise operators…
- … there is a good chance that this formulation runs faster as compared to any other equivalent formulation
- You’ll understand the reasons for the same during your course on Computer Organisation

Homework !!

Read more about bitwise operators, especially if you wish to use them in your code

- This compact article is a nice read: https://www.geeksforgeeks.org/bitwise-operators-in-c-cpp/

Probably the most useful bitwise operator is the ^ operator

- Open some of the links provided on the above page to get an idea of its utility