Bitwise Operations, Bit Fields

Bitwise Operations

Bitwise Operators

x	y	x|y	x&y	x^y
0	0	0	0	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	0

- **AND (&)** outputs 1 only when both input bits are 1
- **OR (|)** outputs 1 when either input bit is 1
- **XOR(^)** outputs 1 when either input is exclusively 1(i.e., when two input bits are different)
- **NOT(~)** inverts 0 to 1 and 1 to 0

https://fresh2refresh.com/c-programming/c-operators-expressions/c-bit-wise-operators/

Exercise 2

x & 0	
x|0	
x^0	
x&1	
x|1	
x^1	

Exercise 2

x & 0	0
x|0	x
x^0	x
x&1	x
x|1	1
x^1	~x

x ^ 1

x = 0: 0 ^ 1 = 1 = ~x

x = 1: 1 ^ 1 = 0 = ~x

Masking to extract Bits

- Given binary number **0b1000 0001 1110 1011**, extract only the last 4 LSB bits

Bit 1	Bit 2	Bitwise AND
1	Y	Y
0	Y	0

Num 1 : **0b1000 0001 1110 1011**

& **0b0000 0000 0000 1111**

Result : **0b0000 0000 0000 1011**

Masking Bits to 1

- Given binary number **0b1000 0001 1100 1011**, convert the last 8 bits to 1

Bit 1	Bit 2	Bitwise OR
1	Y	1
0	Y	Y

Num 1 : **0b1000 0001** 1100 1011

| **0b0000 0000 1111 1111**

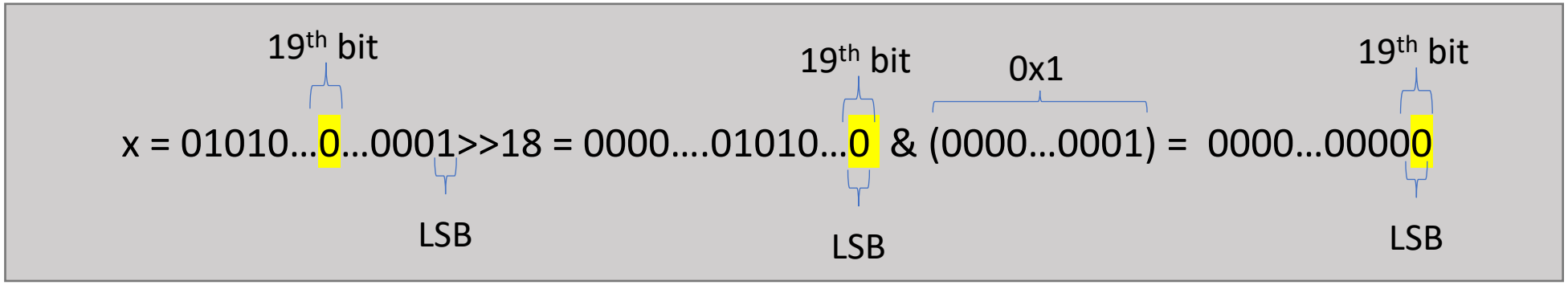
Result : **0b1000 0001 1111 1111**

Exercise

- What is x << n equivalent to?
  - x^n
  - 2^{nx}
  - n^x
  - $x.2^n$

Exercise

- Assume x is a 32-bit number. How do you get the 19th bit from LSB?
  - (x >> 18) & 0x1

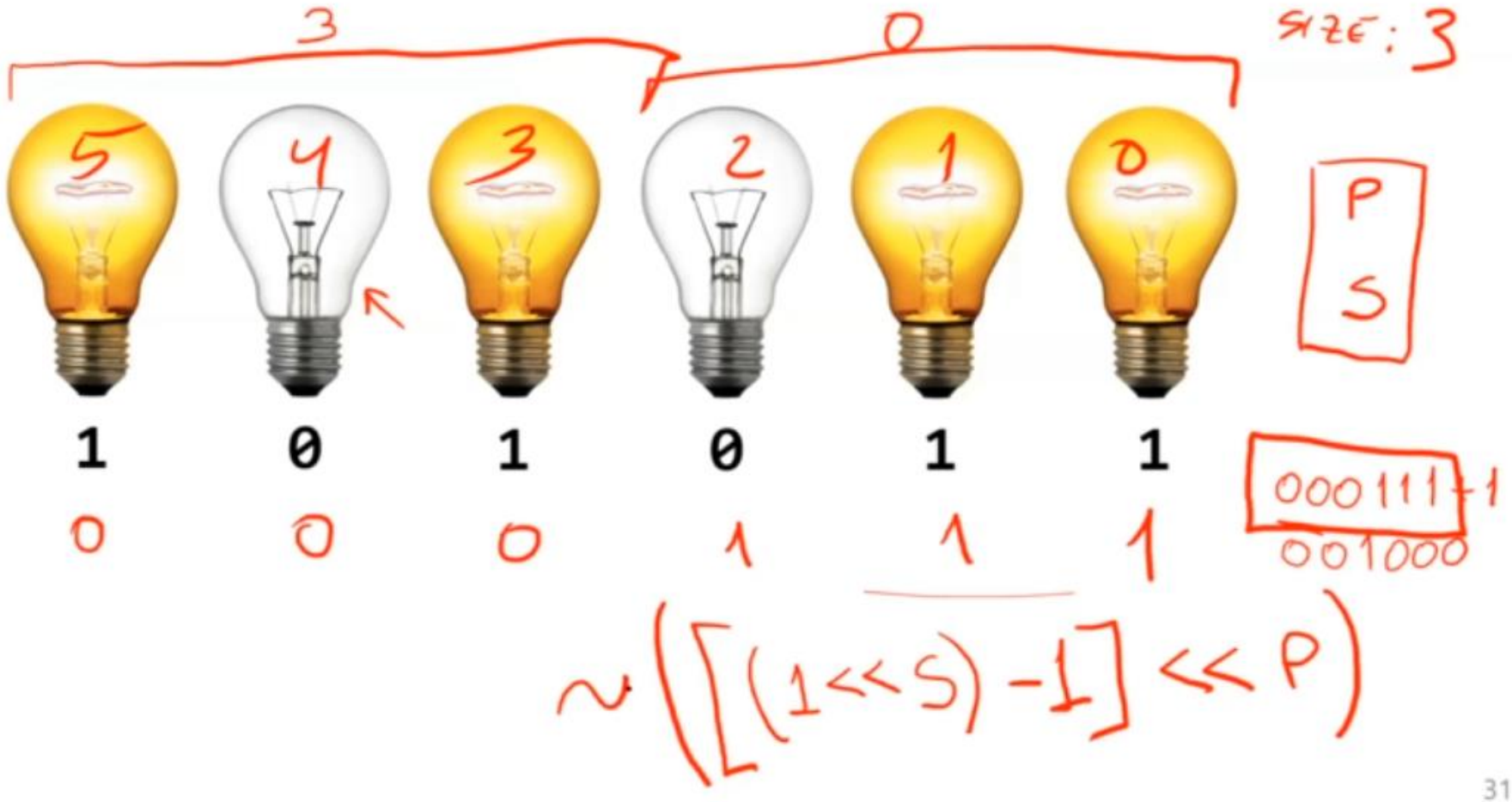


Exercise

- Convert from 0011 0101 1001 0001 -> 0000 0000 0000 1011
  - Assume x = 0011 0101 1001 0001
  - Step 1: x << 4
    - x = 0101 1001 0001 0000
  - Step 2: x >> 11
    - x = 0000 0000 0000 1011

Turning off the first three, leaving the others alone

- more bits, but one of the same operations...

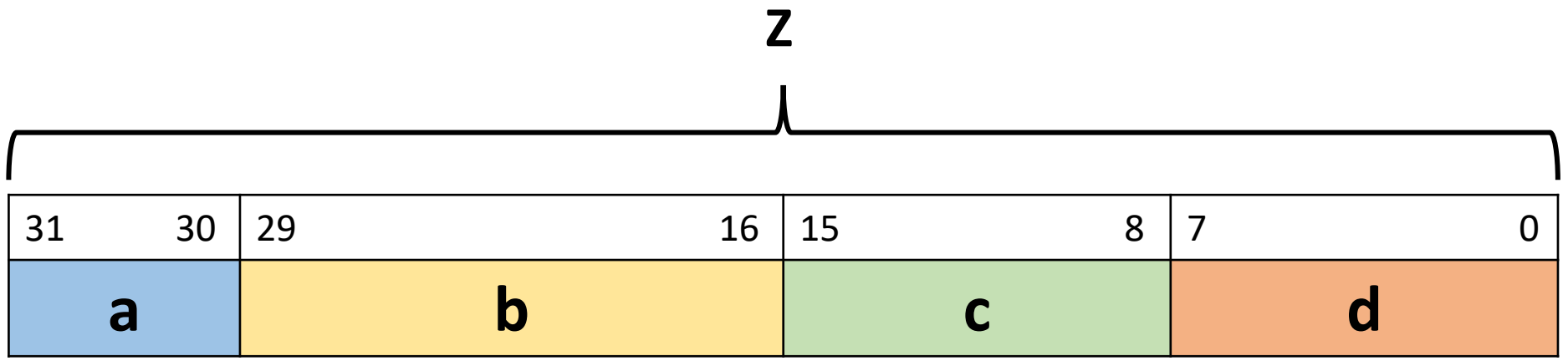


https://luisfnqoliveira.gitlab.io/cs447_s2021/slides/09-Bitwise-Operations.pdf

Exercise

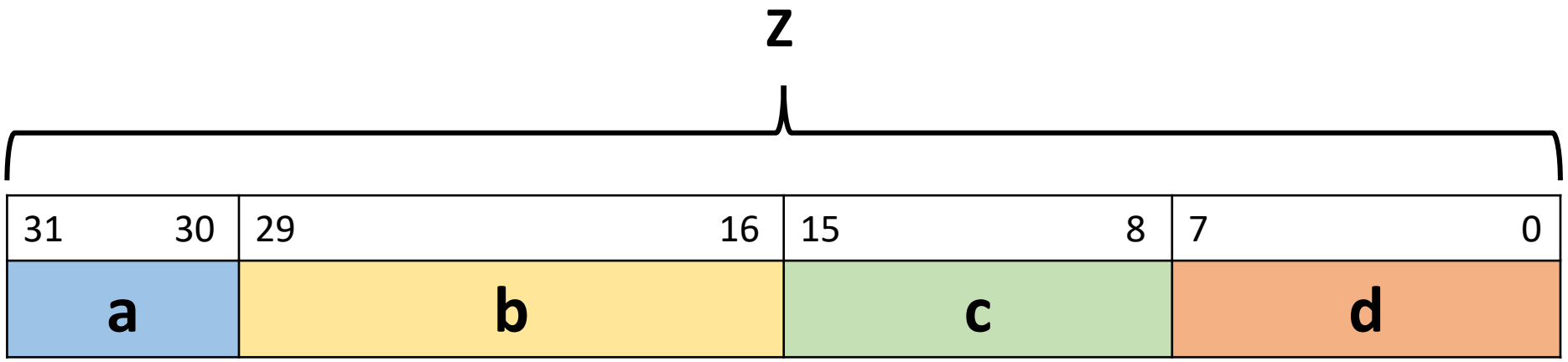
- Convert from 0101 1010 1010 -> 0101 0000 1010
  - Concept 1: 0 & 1 = 0
  - Concept 2: 111 + 1 = 1000 or we can say 1000 – 1 = 111
  - Step 1: Get the number 1111 0000 1111
    - (1<<4) - 1 = 10000 – 1 = 1111
    - 1111 << 4 = 1111 0000 = 0000 1111 0000
    - ~(0000 1111 0000) = **1111 0000 1111**
  - Step 2: **0101 1010 1010 & 1111 0000 1111 = 0101 0000 1010**

Bit Fields



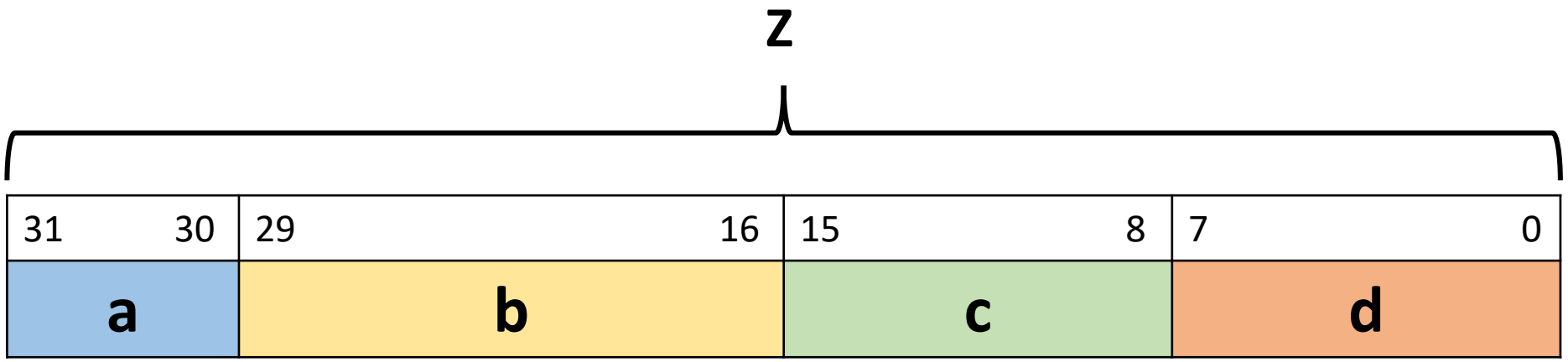
What is the position of the following fields?

- a
  - 30
- b
  - 16
- c
  - 8
- d
  - 0



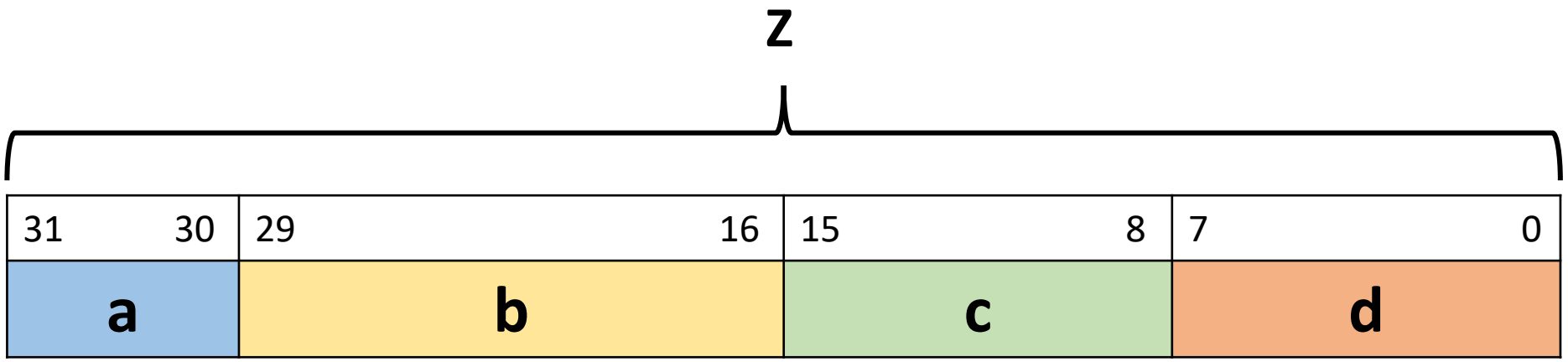
What is the mask of the following fields?

- a
  - 0x03
- b
  - 0x3FFF
- c
  - 0xFF
- d
  - 0xFF



Write the formula to obtain the value of Z in terms of a, b, c and d. (using bitwise operation(s)).

- Z = (a<<30) | (b<<16) | (c<<8) | d



Write the formula to obtain the value of the following fields in terms of Z (using bitwise operation(s)).

- a
  - a = (Z>>30) & 0x03
- b
  - b = (Z>>16) & 0x3FFF
- c
  - c = (Z >> 8) & 0xFF
- d
  - d = Z & 0xFF