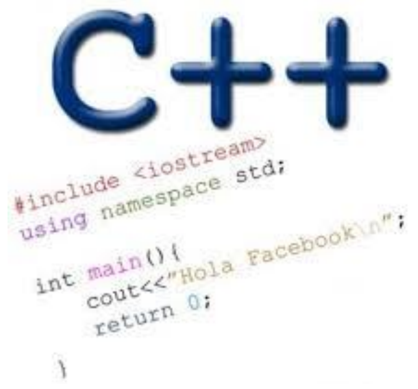
# OPERATOR PRECEDENCE, DATA REPRESENTATION

Problem Solving with Computers-I

https://ucsb-cs16-wi17.github.io/



```
#include <iostream>
using namespace std;

int main(){
    cout<<"Hola Facebook\n";
    return 0;
}
```

## Announcements

- Midterm next week –Thursday (02/02)
- Study guide will be posted by tomorrow at this location: https://ucsb-cs16-wi17.github.io/exam/e01/
- Midterm will cover topics from
  - Lectures 1 to 7 (including code covered in class)
  - Labs 0 to 2
  - Homeworks 1 to 6

## Review homework 4, problem 3

What is the output of the following program?

```
int x = 0;
while ( x = 2 && x < 10){
    cout << x << endl;
    x+=2;
}
```

A. Nothing is printed to output
B. Infinitely prints the number 2
C. Infinitely prints the number 1
D. Prints the following numbers to output: 2 4 6 8

## Operator Precedence

Parathesis () does not mean “Do what is inside the parenthesis first” It specifies how to explicitly bind operators to operands

```
w = x*(y+z)+y*z;

w =(x = 2) && (x < 10);
```

Operator precedence: Default binding of operators to operands in the absence of parenthesis

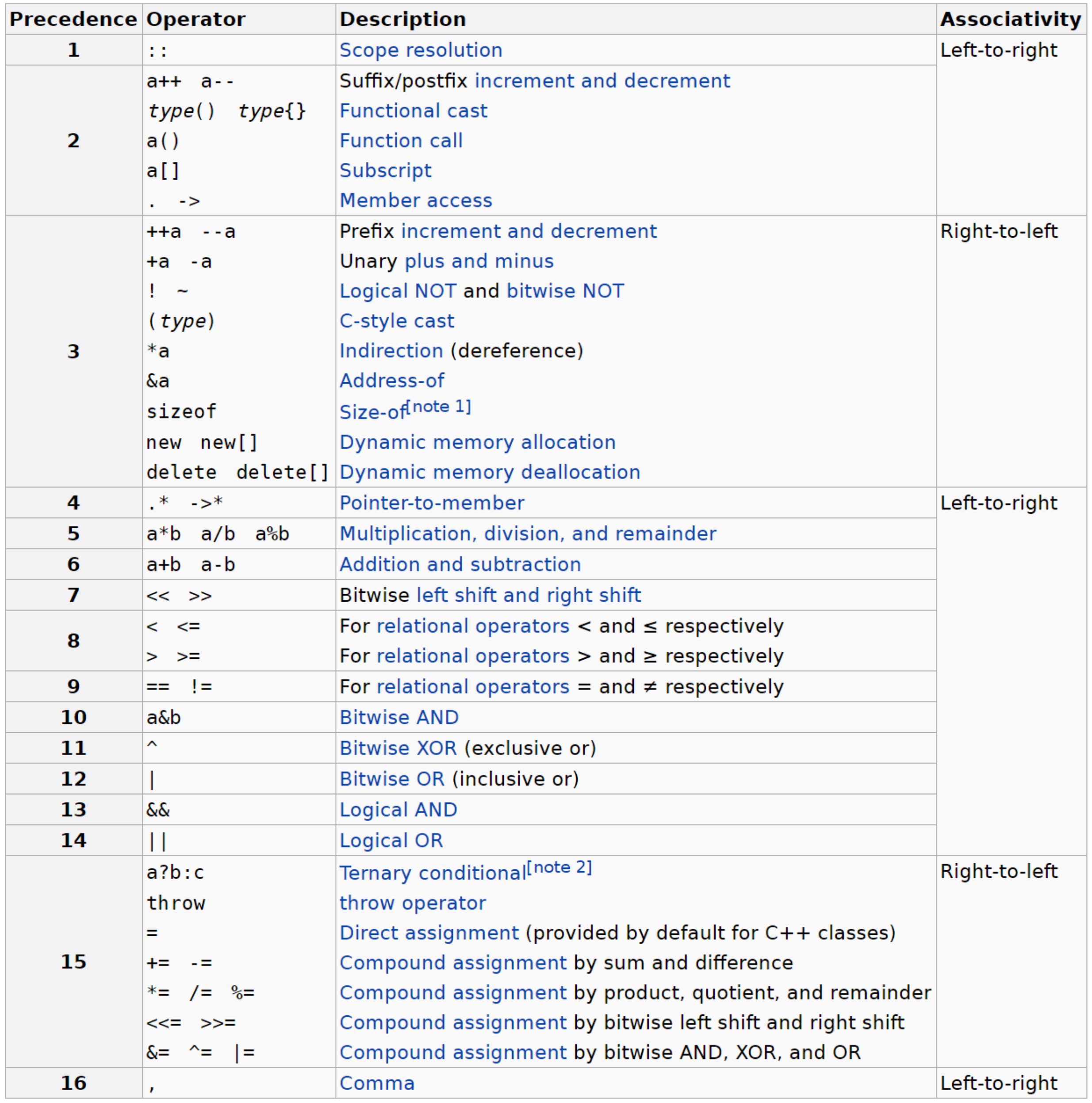
```
w = x * y + z + y * z;
x = a + b * c;
x = a || b && c;
x = a++ + 10;
x = 2 && x < 10;
```

# Operator Precedence

```
int w, x(0);
w = (x = 2) && (x < 10);


w = (x = (2 && x) < 10));


w = (x = 2 && x < 10);
```



| Precedence | Operator | Description | Associativity |
|---|---|---|---|
| 1 | `::` | Scope resolution | Left-to-right |
| 2 | `a++ a--` | Suffix/postfix increment and decrement | |
| | *type*`()` *type*`{}` | Functional cast | |
| | `a()` | Function call | |
| | `a[]` | Subscript | |
| | `. ->` | Member access | |
| 3 | `++a --a` | Prefix increment and decrement | Right-to-left |
| | `+a -a` | Unary plus and minus | |
| | `! ~` | Logical NOT and bitwise NOT | |
| | `(`*type*`)` | C-style cast | |
| | `*a` | Indirection (dereference) | |
| | `&a` | Address-of | |
| | `sizeof` | Size-of[note 1] | |
| | `new new[]` | Dynamic memory allocation | |
| | `delete delete[]` | Dynamic memory deallocation | |
| 4 | `.* ->*` | Pointer-to-member | Left-to-right |
| 5 | `a*b a/b a%b` | Multiplication, division, and remainder | |
| 6 | `a+b a-b` | Addition and subtraction | |
| 7 | `<< >>` | Bitwise left shift and right shift | |
| 8 | `< <=` | For relational operators < and ≤ respectively | |
| | `> >=` | For relational operators > and ≥ respectively | |
| 9 | `== !=` | For relational operators = and ≠ respectively | |
| 10 | `a&b` | Bitwise AND | |
| 11 | `^` | Bitwise XOR (exclusive or) | |
| 12 | `\|` | Bitwise OR (inclusive or) | |
| 13 | `&&` | Logical AND | |
| 14 | `\|\|` | Logical OR | |
| 15 | `a?b:c` | Ternary conditional[note 2] | Right-to-left |
| | `throw` | throw operator | |
| | `=` | Direct assignment (provided by default for C++ classes) | |
| | `+= -=` | Compound assignment by sum and difference | |
| | `*= /= %=` | Compound assignment by product, quotient, and remainder | |
| | `<<= >>=` | Compound assignment by bitwise left shift and right shift | |
| | `&= ^= \|=` | Compound assignment by bitwise AND, XOR, and OR | |
| 16 | `,` | Comma | Left-to-right |

## Operator Associativity

Operator associativity: Deals with operators that are at the same precedence level or group

- Some groups associate from **left to right** e.g. Arithmetic

  x= a + b – c + d;

- Other groups associate from **right to left** e.g. Assignment

  x= y = z = 50;

## Order of evaluation

- Deals with which side of an operator is evaluated first (Lt operand or Rt operand). Java/Python strictly defines Lt->Rt. C/C++ do not define order of evaluation

```
b=3;
b = b +(b=9);

a =5;
x= a + a++;

int i =4;
cout<< i++ * ++i;
```

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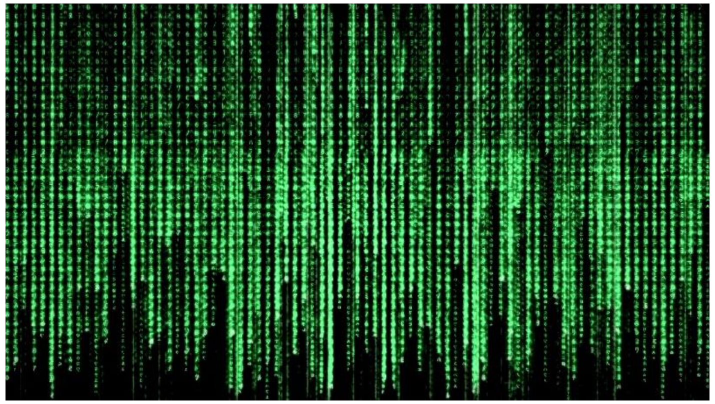
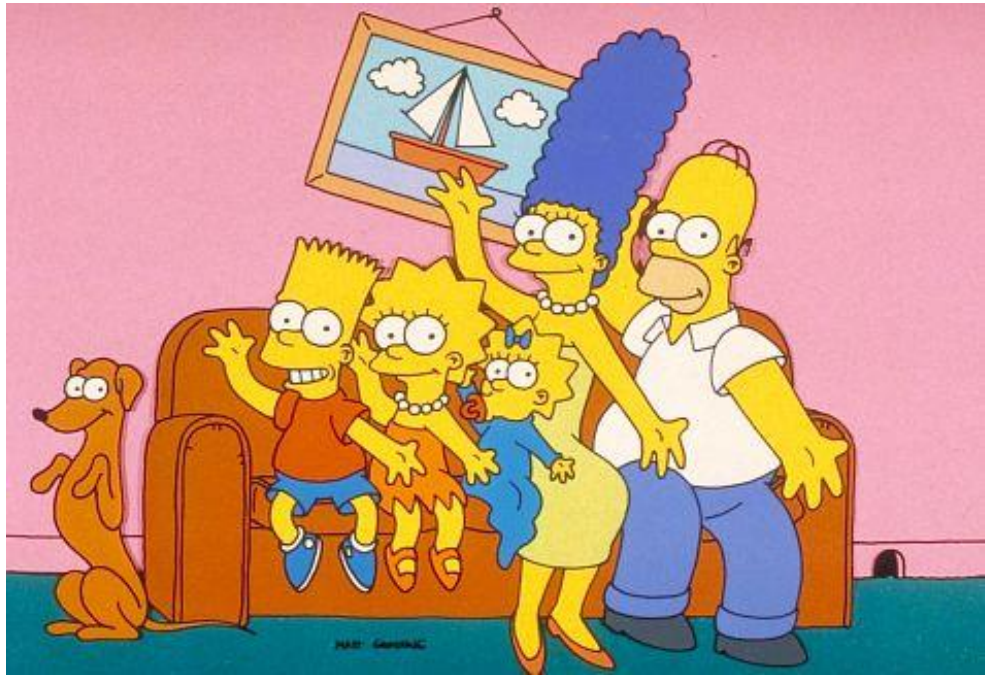
## What does ‘data’ on a computer look like?

- Imagine diving deep into a computer
- Expect to see all your data as high and low voltages
- In CS we use the abstraction:
  - High voltage: 1 (true)
  - Low voltage: 0 (false)



## Decimal (base ten)

- Why do we count in base ten?
- Which base would the Simpson's use?



## Positional encoding

- Non-negative numbers represented using *positional encoding*
- Each position represents some power of the base

| Base | Digits | Example |
|---|---|---|

Why is each base important??

## Binary representation (base 2)

- Used by the machine
- Only two symbols: 0 and 1
- Each position is called a *bit*
- What is the decimal equivalent of the binary number:

0 1 0 1

## $101_5$ = ? In decimal

A. 26

B. 51

C. 126

D. 130

## Generalized positional encoding

- Polynomial expansion

## External vs. Internal Representation

- External representation:
  - Convenient for programmer

- Internal representation:
  - Actual representation of data in the computer’s memory and registers: Always binary (1’s and 0’s)

## Converting between binary and decimal

$1\ 0\ 1\ 1\ 0_2$ = ? In decimal

Decimal to binary: $34_{10}=?_2$

## Hex to binary

- Each hex digit corresponds directly to four binary digits
- Programmers love hex, why?

$35AE_{16}$ = ? In binary

| | | |
|---|---|---|
| 00 | 0 | 0000 |
| 01 | 1 | 0001 |
| 02 | 2 | 0010 |
| 03 | 3 | 0011 |
| 04 | 4 | 0100 |
| 05 | 5 | 0101 |
| 06 | 6 | 0110 |
| 07 | 7 | 0111 |
| 08 | 8 | 1000 |
| 09 | 9 | 1001 |
| 10 | A | 1010 |
| 11 | B | 1011 |
| 12 | C | 1100 |
| 13 | D | 1101 |
| 14 | E | 1110 |
| 15 | F | 1111 |

## Binary to hex: 1000111100

A. 8F0

B. 23C

C. None of the above

## Hexadecimal to decimal

$25B_{16}$ = ? Decimal

## Hexadecimal to decimal

- Use polynomial expansion

- $25B_{16}$ = 2*256 + 5*16 + 11*1 = 512 + 80 + 11

  = 603
- Decimal to hex: $26_{10}=?_{16}$

# Decimal vs. Hexadecimal vs. Binary

Examples:

1010 1100 0011 (binary)
= 0xAC3

10111 (binary)
= 0001 0111 (binary)
= 0x17

0x3F9
= 11 1111 1001 (binary)

| | | |
|---|---|---|
| 00 | 0 | 0000 |
| 01 | 1 | 0001 |
| 02 | 2 | 0010 |
| 03 | 3 | 0011 |
| 04 | 4 | 0100 |
| 05 | 5 | 0101 |
| 06 | 6 | 0110 |
| 07 | 7 | 0111 |
| 08 | 8 | 1000 |
| 09 | 9 | 1001 |
| 10 | A | 1010 |
| 11 | B | 1011 |
| 12 | C | 1100 |
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# BIG IDEA: Bits can represent anything!!

- Logical values?
  - 0 ⇒ False, 1 ⇒ True
- colors ?
- Characters?
  - 26 letters ⇒ 5 bits ($2^5 = 32$)
  - upper/lower case + punctuation
    ⇒ 7 bits (in 8) (“ASCII”)
  - standard code to cover all the world’s languages ⇒ 8,16,32 bits (“Unicode”)
    [www.unicode.com](www.unicode.com)
- locations / addresses? commands?

*Red*

*Green*

*Blue*

- MEMORIZE: N bits ⇔ at most $2^N$ things

## Next time

- Under the hood of program compilation
- Separate compilation with makefiles