




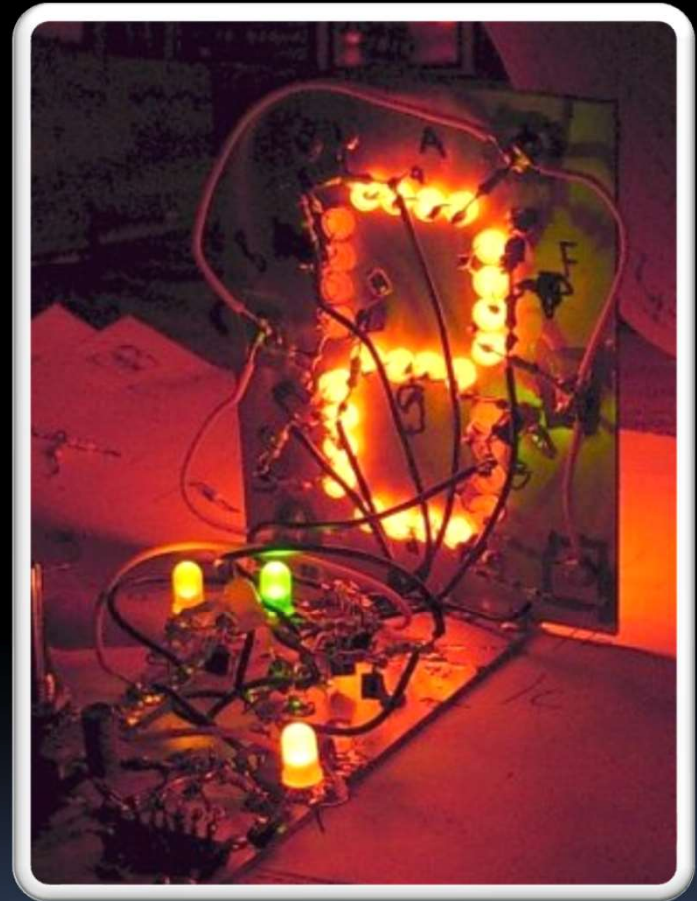
CSC258: Computer Organization



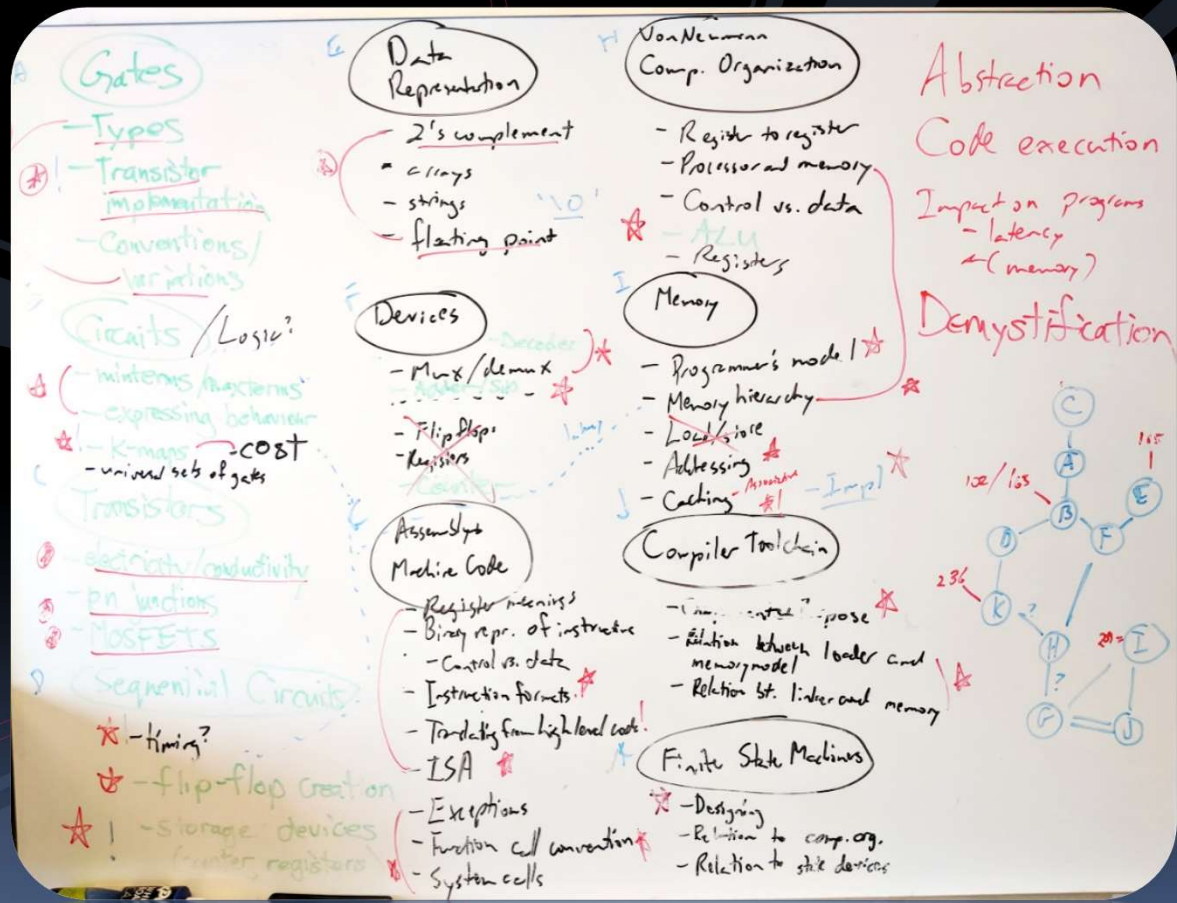
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What we're covering today

- A little about us
- What CSC258 is about
- What CSC258 involves
- Course outcomes
- Next steps



What is CSC258 about?



How does your computer work?

- To understand computer software, you need to understand computer hardware.

Limitations

Why is the maximum integer value $2^{32}-1$?

Operations

What is a pointer? How is memory allocated?

Behaviour

What is a stack overflow? How do exceptions work? What causes a blue screen error?

Example: True and False

- How does Python evaluate `true` and `false`?
 - Example: `if` statements:

```
if x:  
    print 'Hello World'  
# what values of x will make this  
# print statement happen?
```

- What if `x` is a Boolean?
- What if `x` is an integer?
- What if `x` is a string?

Do the answers to
these questions have
something in common?

True and False in Python

- Values that are treated as “false”:

- Constants defined to be “false”:
 - `None` and `False`.
- Numeric zero values:
 - `0`, `0.0`, `Decimal(0)`, `Fraction(0,1)`
- Empty sequences and collections:
 - `''`, `()`, `[]`, `{}`, `set()`, `range(0)`

"By default, an object is considered true unless its class defines either a `__bool__()` method that returns `False` or a `__len__()` method that returns zero, when called with the object."

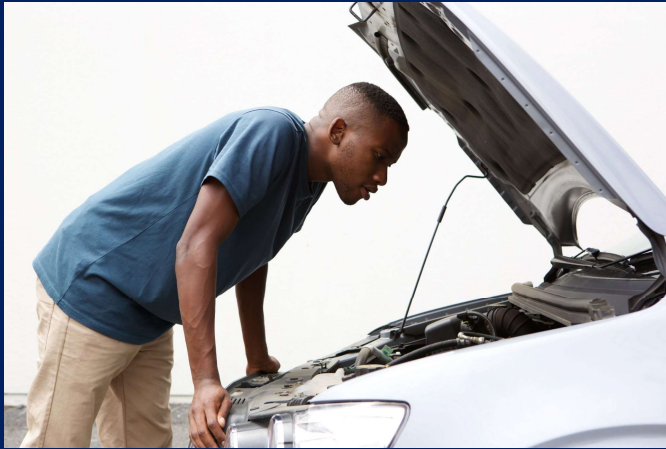
<https://docs.python.org/3/library/stdtypes.html#truth-value-testing>

- What do these “false” values have in common?

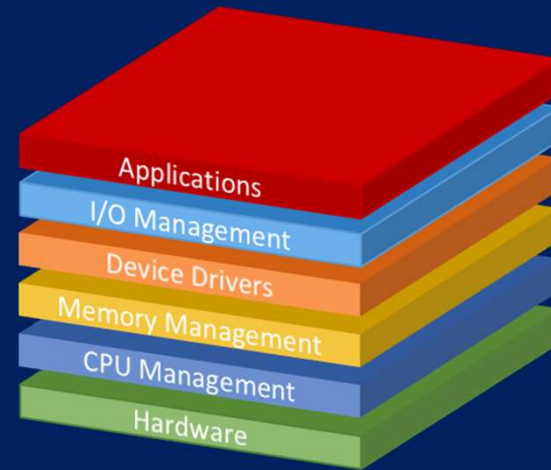
- They're all represented the same way in memory.
 - i.e. Zero vs not zero
- One of the many things you learn in CSC258 😊

Why are you taking CSC258?

Understanding the machine



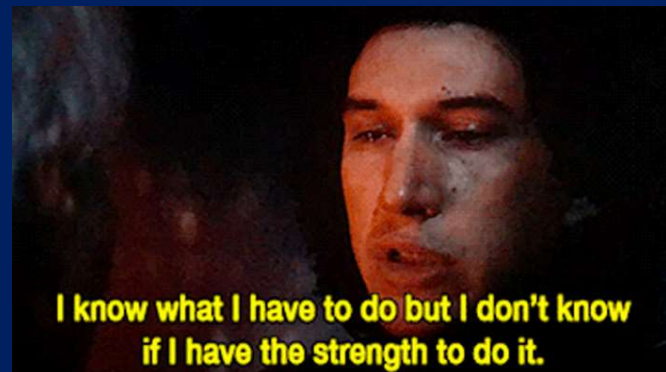
Satisfying prerequisites



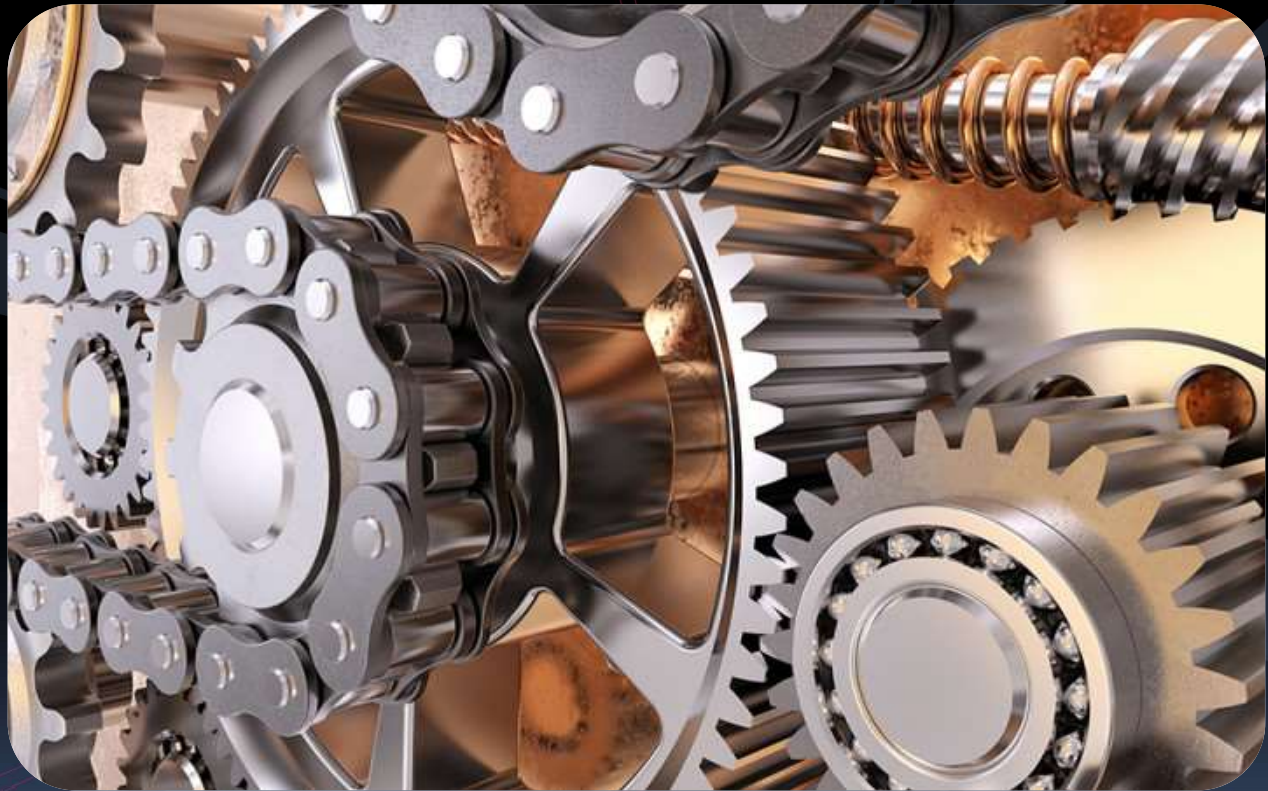
Working with devices (IoT)



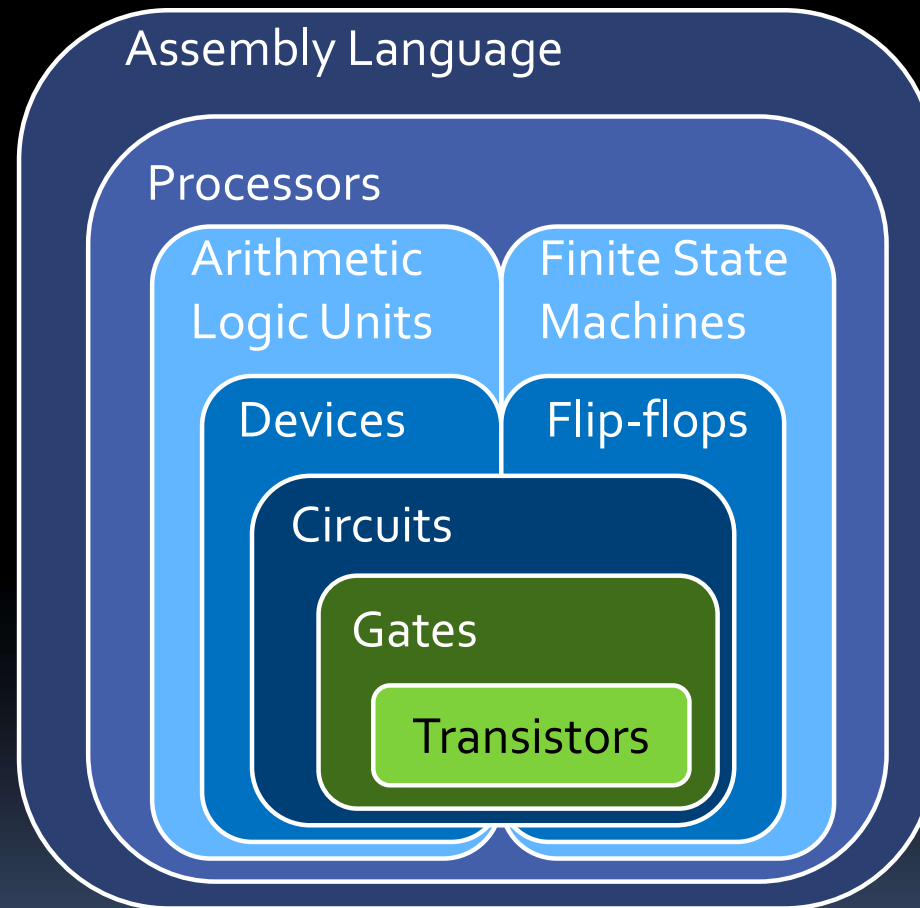
Because you have to



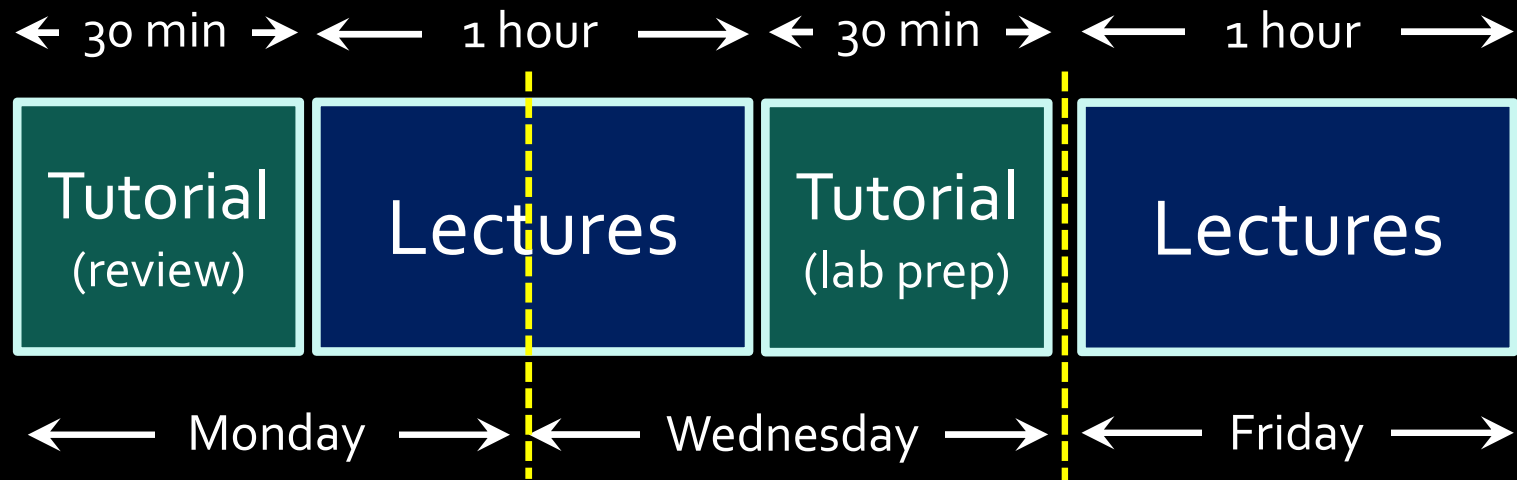
How the course works



The course at a glance



Lectures & Tutorials



- **Lectures** (2 hours total)
 - Lectures cover course topics (generally one per week)
 - Each week builds on the week before
 - 2022 recordings will be available on Quercus
- **Tutorials**
 - Monday: 30 minutes topic review (from previous week)
 - Wednesday: 30 minutes lab prep (for following week)

Lab Exercises

- **Labs (28%):**

- 7 total (4% each)

- One lab per week, starting in Week 2 (week of Jan 16th)

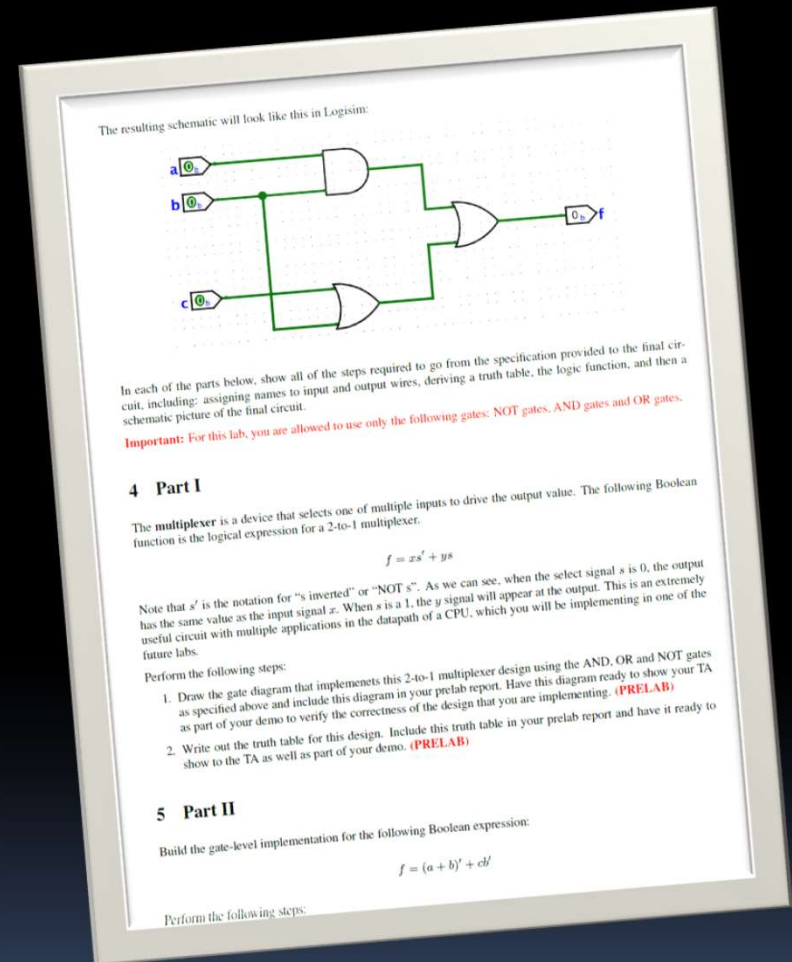
- Each lab consists of two parts:

- **Pre-lab** → **1%**

- Circuit creation exercises
- Submit on Quercus before lab

- **Demo** → **3%**

- Performed for TAs in labs
- Minimum standard questions



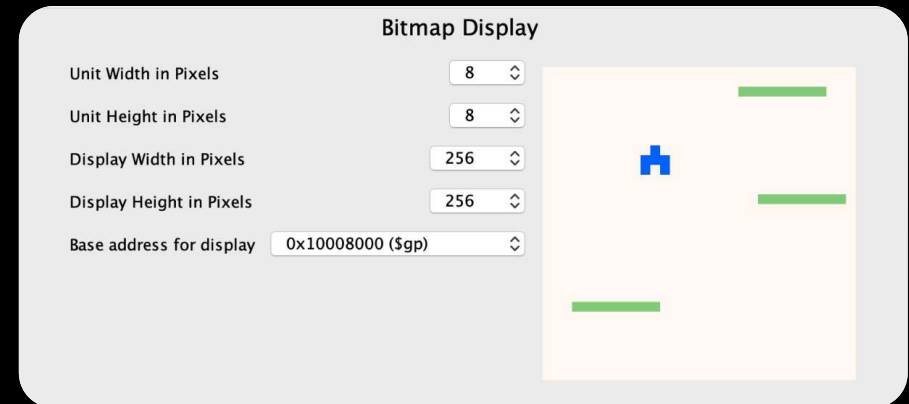
How do the labs work?

- Everybody has 3 hours of lecture time and a **3-hour lab time** assigned to this course.
 - L0101 lab time: Wednesdays, 6pm-9pm
 - L0201 lab time: Mondays, 6pm-9pm
 - L5101 lab time: Thursdays, 6pm-9pm
- Students attend their lab session and sit at their designated station (assigned during the first lab in Week 2)
 - **Pre-labs** exercises are submitted before the lab,
 - Completed work is demonstrated during the lab session.
- Labs take place in BA3145, BA3155 and BA3165.
 - Students are assigned to a lab room according to last name (see Quercus to know which room you're in).

Project

- **Assembly Language Project (15%):**

- Create an interactive game in MIPS assembly.
- 5 cumulative milestones (3% each)
 - Milestones 1-3: Basic game features
 - Milestones 4-5: Advanced features
 - Can demo all 5 in the first week, if you want.
- Milestone demos take place in the lab rooms with the TAs in the final two weeks of the course.
 - Including questions about the design process.



Midterm & Final Exam

- Midterm (19%)

- Tentatively scheduled for Wed Mar 1, 6pm-8pm
- Send email to the course email account if you have a conflict, along with your course schedule.

- Final Exam (38%)

- In-person assessment (3 hours to write)
- Must get 40% on exam to pass the course.
- Exam date will be released midway through the semester.

Course Objectives



Course outcomes

- **Circuit creation**
 - Create combinational and sequential circuits from logic gates.
 - Design circuits that implement Finite State Machines
- **Microprocessor architecture**
 - Implement a basic arithmetic logic unit (ALU)
 - Develop register files and memory units
 - Construct and operate the processor datapath.
- **Assembly basics**
 - Encode and decode microprocessor instructions
 - Translate between assembly and C programs

Building on CSC148

- Hardware knowledge helps us make sense of the software knowledge from CSC148.
 - Think of CSC258 as the prequel to CSC108 and CSC148 (or CSC110 & CSC111)
- CSC258 also complements the material in CSC209.
 - Helps you understand pointers and memory operations.

The image shows two side-by-side screenshots of a code editor. The left window displays C code for a quicksort algorithm. The right window displays the corresponding assembly code. A red arrow points from the `your_sort` function call in the C code to its definition in the assembly code.

```
test.c:~(Desktop)-gedit
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*test.c*
1 while ((numbers[left] <= pivot) && (left < right))
2     left++;
3     if (left != right)
4     {
5         numbers[right] = numbers[left];
6         right--;
7     }
8     numbers[left] = pivot;
9     pivot = left;
10    left = l_hold;
11    right = r_hold;
12
13    if (left < pivot)
14        quick_sort(numbers, left, pivot-1);
15    if (right > pivot)
16        quick_sort(numbers, pivot+1, right);
17
18 void your_sort(int numbers[])
19 {
20     quick_sort(numbers, 0, 199);
21 }
22
23 int main()
24 {
25     int num[200];
26     srand( (unsigned)time(NULL) );
27     for(int i = 0; i < 200; i++){
28         num[i] = rand()%65;
29     }
30     your_sort(num);
31     for(int i = 0; i < 200; i++){
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Building on CSC165 / CSC110

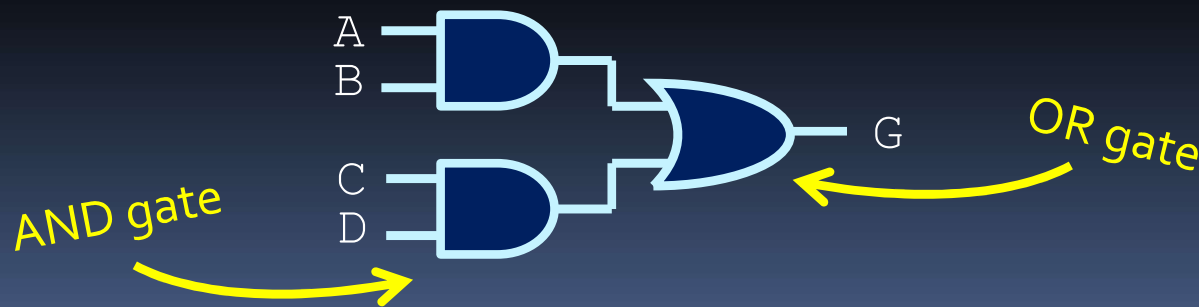
- Logic notation and reasoning is essential in the beginning of the course.
- In CSC165 (or CSC110) you use propositional logic to evaluate statements to be true or false.
- In CSC258 you create circuits whose output value evaluates to true or false, based on the input values.
 - Electrical equivalent of “true” and “false” are high voltage (5V) and low voltage (0V).
 - Also known as binary bits 1 and 0, which we see soon.

Connecting to intro courses

- From CSC165: Create an expression G that is true if the variables A and B are true, or C and D are true.

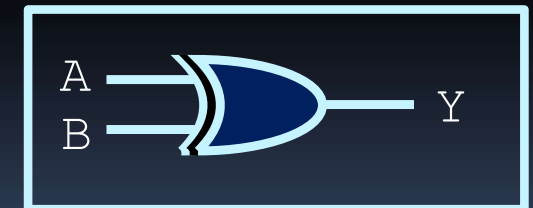
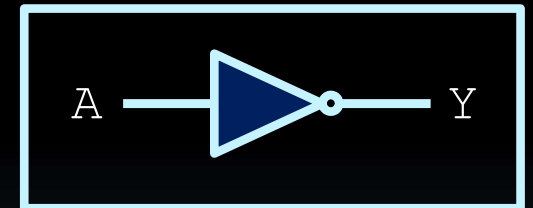
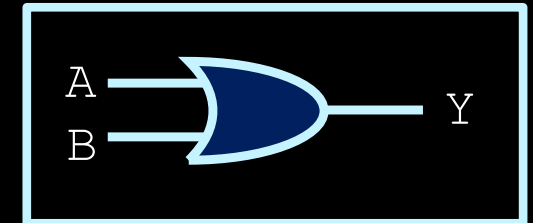
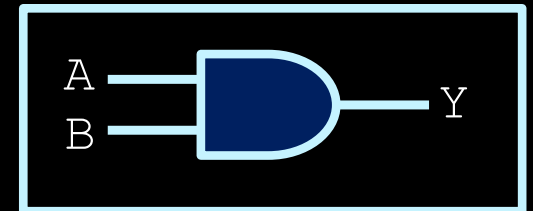
$$G = (A \wedge B) \vee (C \wedge D)$$

- In CSC258: Create a circuit that turns on if inputs A and B are on, or inputs C and D are on:



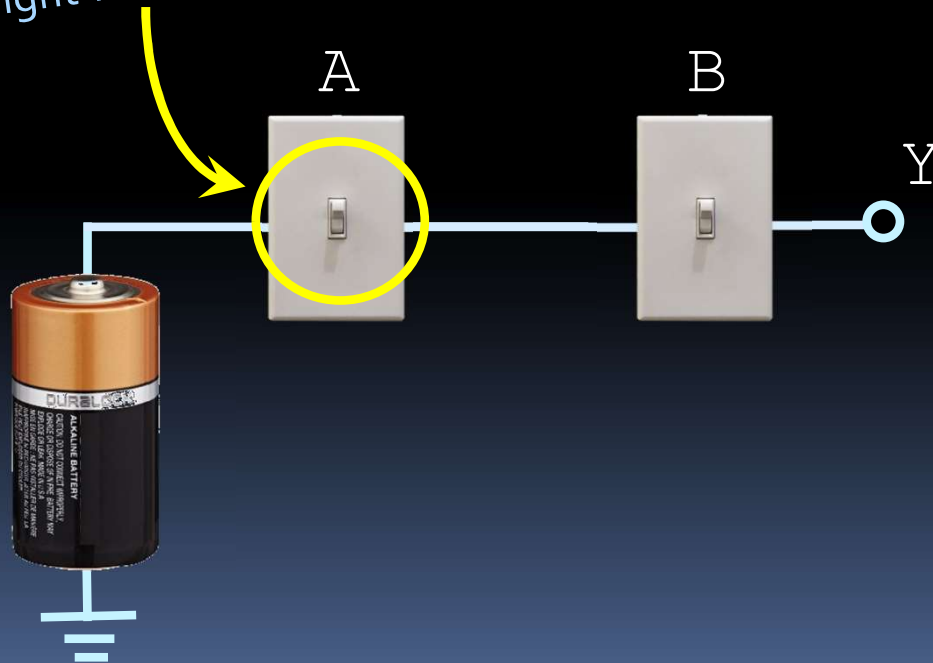
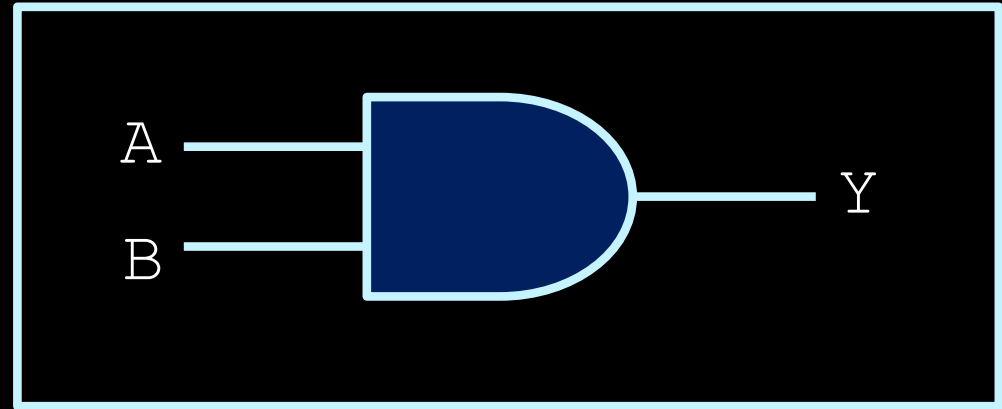
Logic Gates \leftrightarrow Operators

- **Logic gates** are the hardware equivalent of propositional operators in CSC165/CSC110.
 - Like Boolean expressions, gates determine whether the output of a circuit will be on or off as an expression of the input signals.
- Lab 1:
 - Create simple circuits based on logical (Boolean) expressions
 - Display truth tables that show the logical behaviour of these circuits.



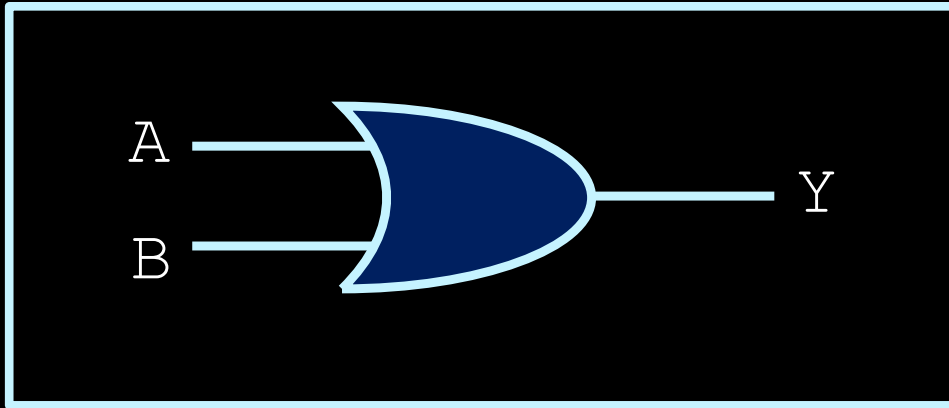
AND Gates

These are implemented by components called **transistors**. We'll learn about them shortly. For now, think of them like switches that connect the left and right when A is turned on.



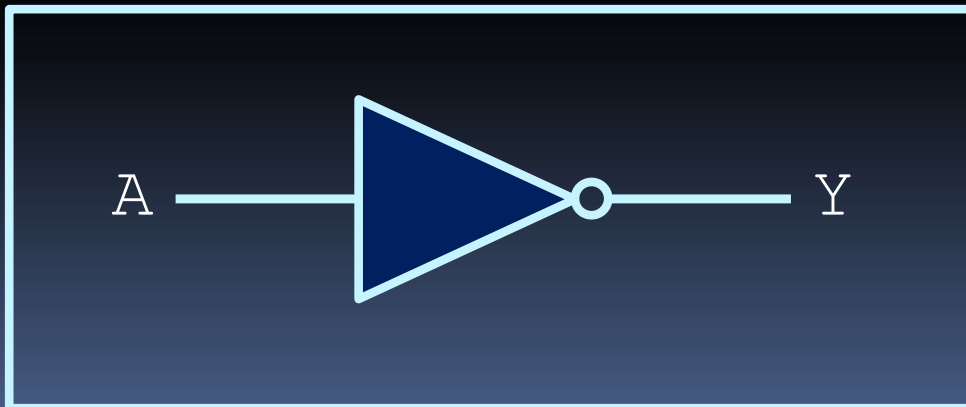
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

OR Gates



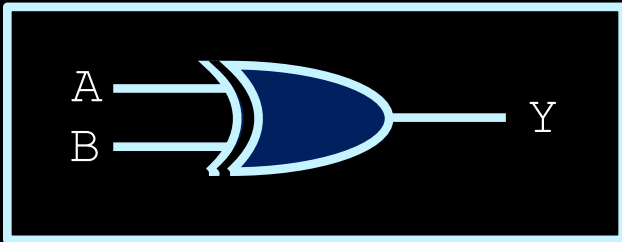
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

NOT Gates



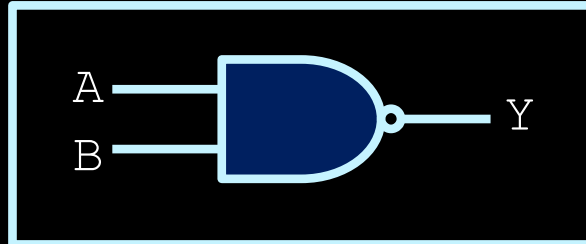
| A | Y |
|---|---|
| 0 | 1 |
| 1 | 0 |

XOR Gates



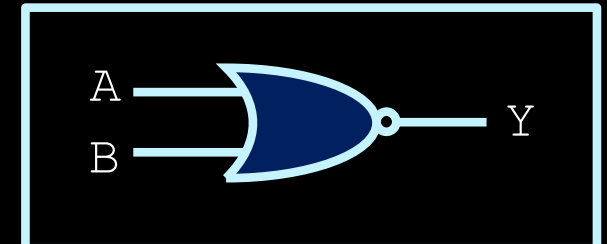
| A | B | Y |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

NAND Gates



| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

NOR Gates

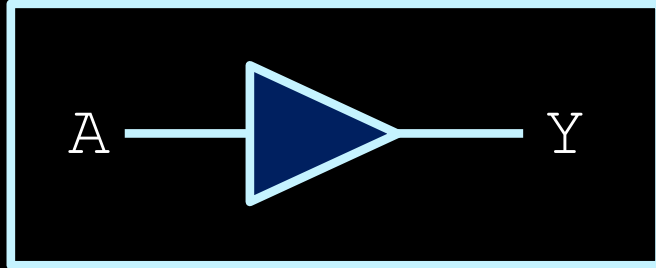


| A | B | Y |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

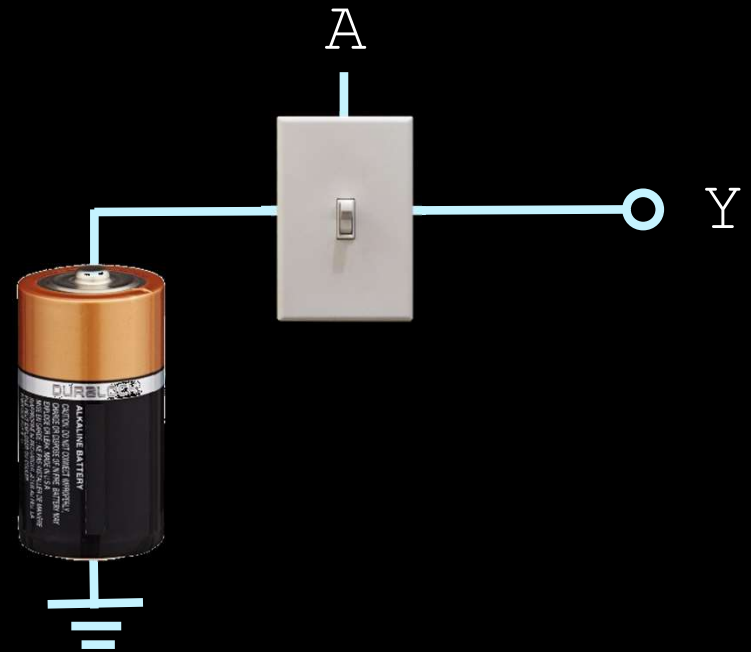
Bill Gates



Buffer



| A | Y |
|---|---|
| 0 | 0 |
| 1 | 1 |



- ...more in Week 9 about what makes this gate useful.

First Steps



Thinking in hardware

- Although CSC258 has elements that are similar to other courses, it is very different in significant ways.
 - Unlike our software courses, CSC258 is not about creating programs and algorithms, but rather devices and machines.
 - Very important concept to grasp early in this course!



Starting from the bottom

- Gates can combine values together like logical operators in C or Java.
- But how do gates work?
 - First, we need to understand electricity.
 - Then, we need to understand **transistors**.
 - Finally, transistors are combined to create logic gates.





Let the learning begin

