Boolean Algebra

CS 2130: Computer Systems and Organization 1
August 29, 2025

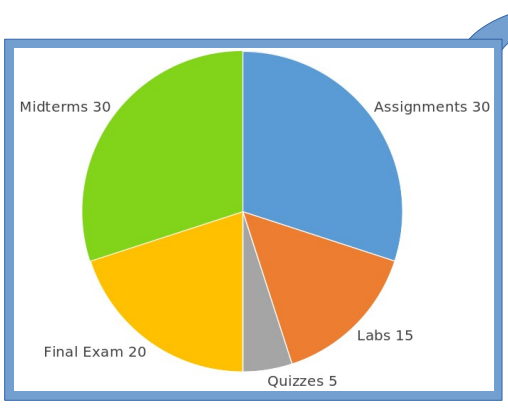
Announcements

If you need to switch labs:

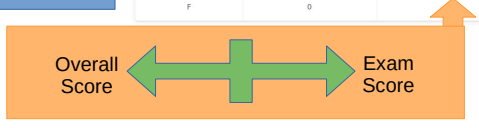
- Form will be coming soon
- Must be justified (i.e. class conflicts)
- **Very** limited space to make swaps

Quiz 0 opens tonight, due Sunday 11:59pm

Measuring Learning: Grading



Letter Grade	Overall Average Lower Bound	and Exam Average Lower Bound
A+	98.0	78.0
A	93.0	73.0
A-	90.0	70.0
B+	87.0	67.0
B	83.0	63.0
B-	80.0	60.0
C+	77.0	57.0
C	73.0	53.0
C-	70.0	50.0
D+	67.0	47.0
D	63.0	43.0
D-	60.0	40.0
F	0	



Professionalism, Academic Integrity

Honesty

- No plagiarism: cite any and every source you consult (even GenAI)
- **Write your own code**: Compose it yourself
  - Programming to help learn the content and demonstrate knowledge
  - Unlike industry, in which programming to create product
  - We are looking to cultivate our minds

Professionalism, Academic Integrity

Honesty

- Working with others is not okay (by default)
- Asking Generative AI to solve your assignments is not okay (by default)
- Do **not** share your code (even if you are just trying to help)

Consequences of dishonesty are outlined in our Syllabus

Generative AI / LLMs

LLMs are great! Generative AI is the future! But...

- Expert generative AI use requires expertise
- We need the background knowledge to guide our use of Gen AI

Guidance for this class

- **Do NOT use it** to solve homework or generate answers
  - The problem-solving struggle *is* a good struggle for learning
- **Do use it** for context, extra practice problems, cleaning up grammar, wordsmithing your (own) answers

Expectations and Evaluations

Illness Policies

- Attendance is **not** required in lecture, but course engagement is!
  - Watch lecture videos
  - Discuss on Piazza
  - Practice in Lab
- If you don't feel well, stay home, it will be okay
  - Will work with you–if you stay home–to ensure no effect to grade
- Masks are always welcome in class

Editors

Editors and Writing Code

- Familiarity with the command line **is a goal of this course**
- Setup and practice in Lab 1 and future labs
- You may **not** use online compilers or editors
  - Using an online compiler will result in a 0 on that assignment
- We will **not** be using VSCode until later
- We will ask you to run your code on the CS portal

This is a Large Class

How can you get your questions answered?

- Piazza (!!)
  - If you know an answer to someone else's question, answer it!
  - We're in it together for the next semester
  - But remember: do NOT share code or solutions
- TAs (office hours and labs)
- My office hours

This is a Large Class

How can you get your questions answered?

- Course email: cs2130@cshelpdesk.atlassian.net
  - Instructors and senior course staff
  - Likely fastest response for direct/personal issues
- My email: jh2jf@virginia.edu
  - Include "CSO1" in the subject
  - Response within a few days

Professor Hott - Who am I? Why teach 2130?

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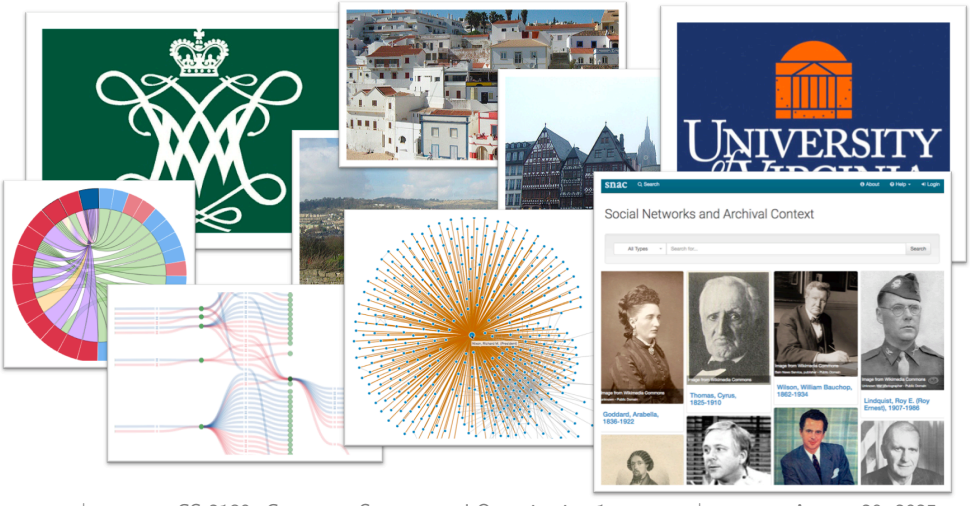


Questions?

Ask me *almost* anything

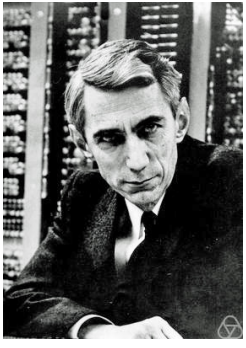
Where to start?

Where to start?

0 and 1

Why only 0 and 1?

Claude Shannon



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Why only 0 and 1?

Vocabulary

- **bit** - either a 0 or 1
- **binary** - a system that has only two positions
- **trinary** - a system that has only three positions
- **quadrinary** - a system that has only four positions
- ...

Vocabulary

- **bit** - either a 0 or 1
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- ...
- **decinary** - ...

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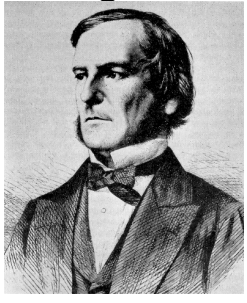
- ...

- **decimal** - system that has ten positions

Boolean Algebra

George Boole



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Putting it together

Overall idea:

- Only need two things (Shannon)
- We can do math with two things (Boole)

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Now we need a physical device that deals in two levels

Transistors

More Vocabulary

Electricity (conceptually) - involves flow of electrons or other charged carriers through a conductive material

- **current** - rate of flow
- **voltage** - pressure of flow

Examples in water

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- High pressure, low flow - squirt gun

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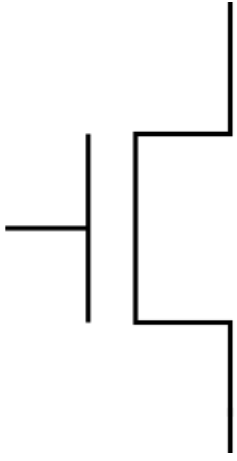
Examples in water

- High pressure, low flow - squirt gun
- Low pressure, high flow - bucket of water

Transistors



Transistors

Transistors act like an electrically-triggered switch

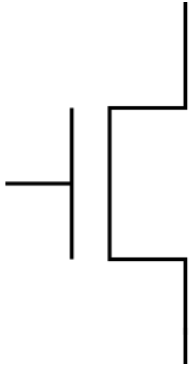
- No voltage, no current
- Apply voltage to allow current to flow

Transistors

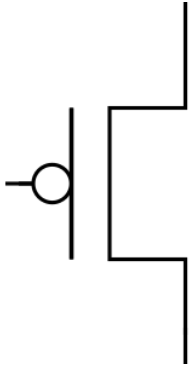
Transistors act like an electrically-triggered switch

- No voltage, no current
- Apply voltage to allow current to flow
- The amount of voltage needed to close the gate is boundary between 0 and 1
- Central technique for how we are going to build binary computers

Transistors



push to close



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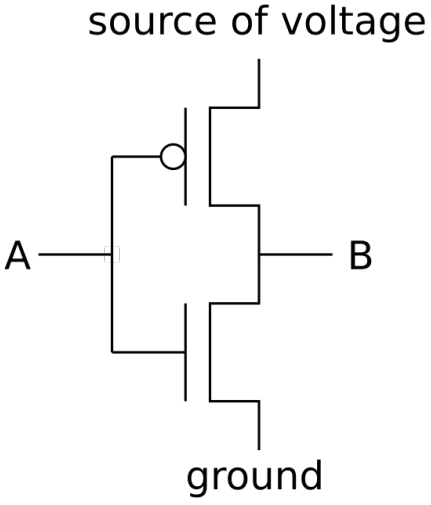
Circuit Diagram



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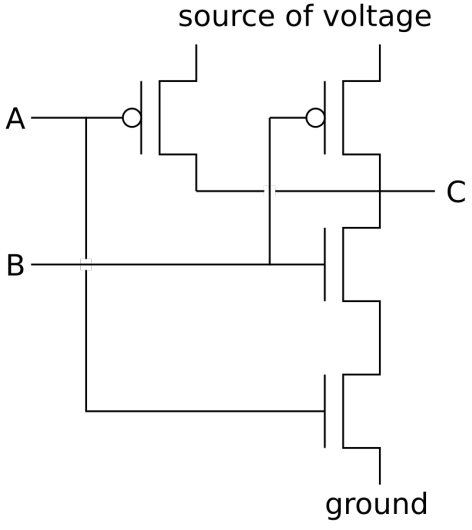

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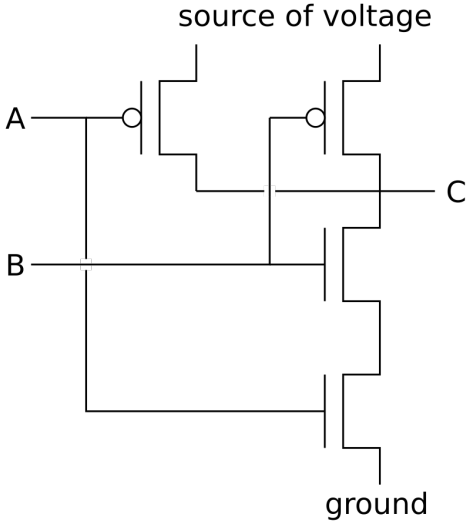

Other Gates (reading)

Building Up

Where we are now

- World with only 2 states: 0 and 1
- Re-developed Boolean logic: and, or, not

Gives us everything Boole talked about

- We can do a lot of interesting things!
- Next: build higher level ideas: the **trinary operator**

Trinary Operator

General idea

```
if ( ... ) {
    ...
} else {
    ...
}
```

Trinary operator (expression if)

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- Python: `x = b if a else c`

Trinary Operator

General idea

```
if ( ... ) {
    ...
} else {
    ...
}
```

Trinary operator (expression if)

- Python: `x = b if a else c`
- Java: `x = a ? b : c`

Multiplexer (mux)

```
x = a ? b : c
```

Multiplexer (mux)

How can we build a mux out of what we have learned so far?

```
x = a ? b : c
```

Multiplexer (mux)

Can be built from `and`, `or`, and `not`

- Can be built using transistors
- Can physically put it in silicon!

Mux will be the key when constructing a computer out of gates and circuits!

Questions?

More bits!

2-bit Multiplexer (mux)

2-bit values instead of 1-bit values