CSCI 161
Introduction to Computer Science

UNIVERSITY of PUGET SOUND
Est. 1888

Department of Mathematics
and Computer Science

Lecture 1
Course overview &
What Are Algorithms?

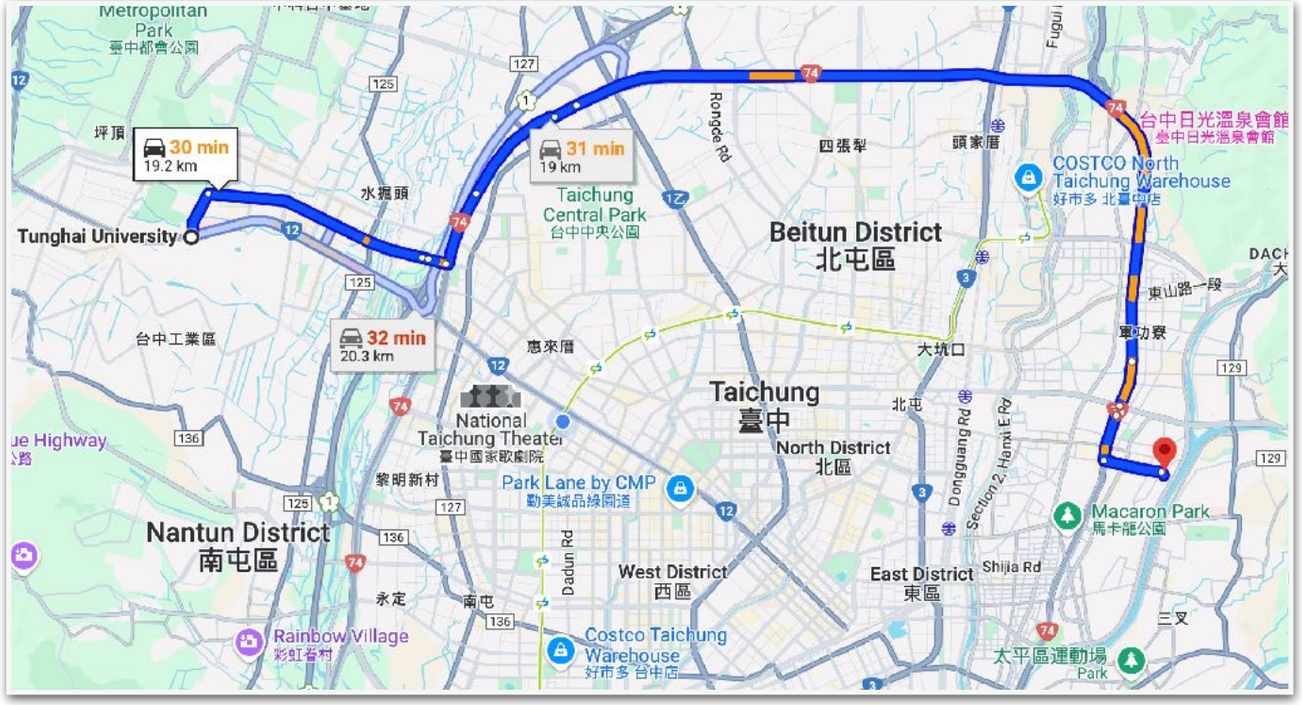
Important

- Two important webpages to bookmark.
  - Course Calendar: tinyurl.com/chiuTHU
    - Notes and code examples
  - iLearn: ilearn.thu.edu.tw
    - Assignment submission

- How to reach me
  - Email: davidchiu@go.thu.edu.tw
  - Line:

Origins in Taichung

- Spent early childhood in Taiwan 1980 - 1985.



About Me

- Moved to Ohio in 1989.
- PhD, Ohio State University in 2010.
- Assistant Professor at Washington State University, 2010-2014
- Full Professor at University of Puget Sound, 2014-now

Ohio State University

Washington State University, Vancouver

My College Campus

- University of Puget Sound (Tacoma, WA)
  - ~ 2000 undergraduate students
  - 60 km south of Seattle, WA (30 minute drive)
  - "Sound?" What sound?

University of Puget Sound Campus

Tacoma, Washington

Seattle, Washington

Puget Sound Surroundings

- Washington state has 3 National Parks
  - Mount Rainier National Park
  - Olympic National Park
  - North Cascades National Park

Gig Harbor, Washington

North Cascades

Olympic

Mount Rainier

Who Are We?

- Please share
  - Your preferred name?
  - Your major?
  - Have you done any kind of programming before?
  - Finally, answer **any one** of the following:

    - What's your go-to comfort food or snack?
    - If you could instantly become an expert in one thing, what would it be?
    - What's a movie or show you could rewatch forever?
    - Do you collect anything? (cards, pins, books, plants…)
    - What's the most unusual thing you've ever eaten?

Grading

- Breakdown
  - 35% Lab Assignments
  - 35% Homework assignments
  - 20% Weekly Quizzes (Fridays)
  - 10% Participation, calculated as follows:
    - $\frac{meetingDays - absentDays}{meetingDays} \times 100$
    - and,
    - $2\ lateDays = 1\ absentDay$

Lab Assignments (Small Group of 2-3)

- Almost daily, done in class. May finish outside of class
  - 2 points = Completed
  - 1 points = Incomplete
  - 0 points = Did not show up, or did not submit
  - Due at 11:59pm, same day.

- Policies
  - Bring your laptop **and** charger to class each day.
  - Strongly encouraged to work with a friend or two.
    - Stay on task and don't disrupt others!
  - Stay off phone and social media!

Homework Assignments (Paired)

- Homework Assignments
  - One homework assigned each week
  - You'll be assigned a different partner each time
  - Due at 11:59pm on specified due date
    - Late penalty: $-3^d\,\%$, where d = days late

- Lots of logic puzzles
  - Leads to **creative** and **critical thinking**
  - Work in pairs, but you can brainstorm with others
    - Copy/pasting others' code or code you find on ChatGPT or Web = academic dishonesty!
    - (More on allowed uses of ChatGPT later)

Weekly Quizzes

- Occurs every Friday
  - Emphasizes on that week's course materials
  - Allowed: 1 page of notes and as much scratch paper as you need.

- Format:
  - Length: 20-30 minutes
  - 5-6 questions per quiz
  - Conceptual questions, code-reading questions, and small code writing questions.

Classroom Participation

- Participation is expected
  - **Please raise your hand** to answer questions 
    - (Instead of blurting out answers while others are still thinking.)
  - I sometimes do small-group work
  - I may ask you to do some "code alongs" with me

- Be attuned to how you present yourself to others
  - For many here, programming is completely new.
  - Don't try to impress others.

Course Policies

- Don't be late.
- Class Disruption
  - Put phone on silent
  - Put laptops away, unless instructed to take them out
    - (Take notes on paper)

- Cheating
  - It's never been easier to compare assignments with ones from the past
  - OK to brainstorm, but *you must write your own code*
  - 0 on assignment + formal report to Tunghai University

AI Policy: Do

- **Do** use it to be your personalized tutor, and that is as far as it should go. Use it to explain concepts you don't fully grasp.
  - Prompt: *"**Without giving me code, explain …**"*

- **Do** use it to explain code to you. Is there a piece of code we went over in class that's hard to grasp? Paste it, and have it explain line-by-line as well as holistically.

- **Do** use it to explain errors to you. Paste your code and the errors you get when compiling or running it. Give hints on what might be the issue.

- **Do** use it to explain any math concepts that you may need to know.

AI Policy: Don't

- **Don’t turn in** anything that was generated by these tools. Copying-and-pasting AI output is considered plagiarism and will be treated as such.

- **Don’t underestimate** how easy it is for us to detect cases where students are turning in code written by generative AI tools.

- **Don’t forget** that you *still* need to demonstrate proficiency on all your exams to pass the course.

Outline

- Course Syllabus
- What Is Computer Science?
  - What are algorithms?
- Conclusion

What Is Computer Science (CS)?

- What is computer science?

"Computer Science is no more about computers than astronomy is about telescopes."

- CS pioneer, Edsger Dijkstra (1930-2002)

- CS is **not:**
  - Using computers competently
  - Building, repairing, troubleshooting computers
  - Coding
  - *(Though, you'll become proficient in the above skills via exposure)*

What Are Algorithms?

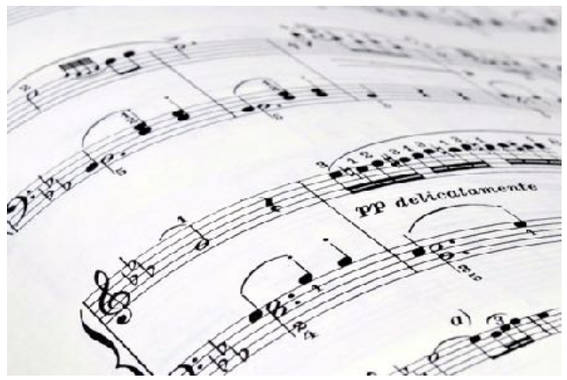
- An *"Algorithm"* is a finite, well-defined sequence of instructions that, when followed (with or without input), produces an output and solves a problem.
  - "finite?"
  - "well-defined?"
  - "input?"
  - "output?"

- What are some algorithms that you apply in your everyday lives?

Real Life Algorithms

- We *"program or code"* + *"execute"* algorithms *all the time!*
  - A recipe to bake an apple pie (*recording* + *baking*)
  - Sheet music (*composing* + *playing*)
  - Formula to find the area of a circle (*recording* + *calculating*)
  - Instructions to set up your wifi

- **Can you think of more?**
- **Key:** algorithms are precise, pre-defined mechanical processes
  - Anyone (or, any *thing*) can carry it out!



Writing an Algorithm

- Pair up with another student, and work together
- **Task:**
  - On a sheet of paper, write an algorithm to purchase a drink at a vending machine.
- **Think critically about:**
  - What inputs, if any, are needed?
  - The desired output?

Class Discussion

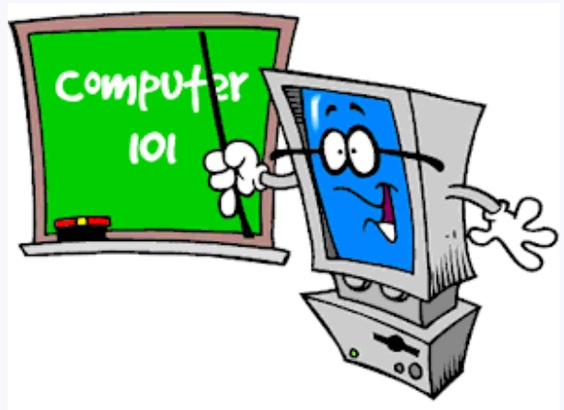
- Did any of your steps assume background knowledge or human intuition?
- Was every instruction unambiguous? Could anyone follow it exactly?
- What would happen if it followed your steps literally?
- What does your algorithm say if the machine is out of stock?
- What if the user doesn’t have enough money?
- What if the selected drink gets stuck — how should the system respond?

Characteristics of Algorithms

- Characteristics of algorithms
  - An algorithm solves a well-defined problem
    - But *some* problems can't be solved algorithmically, so you should know that algorithms (and computers) have limits!
  - There can be *many* algorithms that solve the *same* problem
    - Some algorithms are faster, more elegant and aesthetically pleasing than others.
    - *This is the art of CS!*
  - Algorithms are repeatable and measurable
    - Given the same input, algorithm produce the same result every time.
    - Its performance, energy, space, can all be measured!
    - *This is the science of CS!*

Definition: What Is Computer Science?

- Computer Science is the *study of algorithms*, including their
  - Formal and mathematical properties,
  - Hardware realizations,
  - Linguistic realizations, and
  - Applications



Definition from: Schneider and Gersting. "An Invitation to Computer Science."

- Computers are just tools (hardware) that can carry out algorithms!
  - "Computer Science" is a misnomer
    - It's like calling Chemistry, "Beaker Science"*!*

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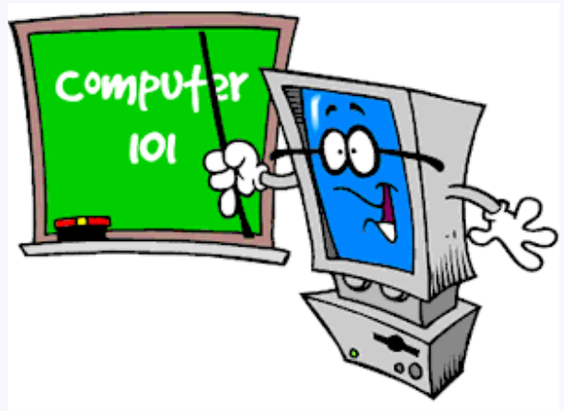

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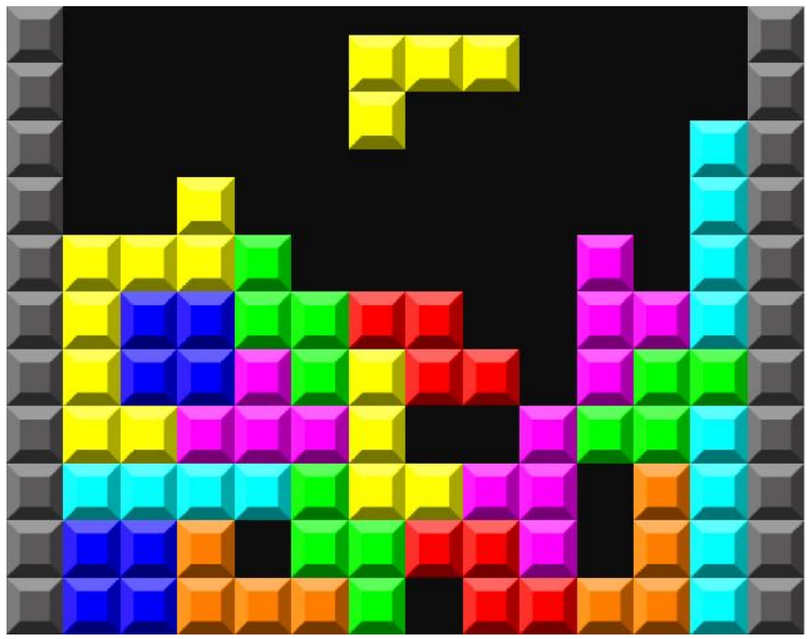
Formal and Mathematical Properties

- There are two fundamental questions in CS theory:
  - Given a yes/no problem, is the problem:
    - Decidable? Can it even be *solved* algorithmically?
    - Hard? If it's solvable, how long would it take to solve it?

- Decidability examples:
  - "Is *P* the shortest path from city *A* to city *B*?"
    - This problem is **decidable**!
  - "Are [3,29,2,0,57] tomorrow's lottery numbers?"
    - This problem is **not decidable!**
    - (Can't solve this one with algorithms)

Formal and Mathematical Properties (2)

- Complexity (Hardness): Can a decidable problem be solved in a reasonable amount of time?
  - Determining the shortest path between City *A* and City *B* is considered easy.
  - "Given a sequence of pieces in Tetris, what's the best way to arrange them?" Hard
    - No known algorithm exists that can answer this question before the end of humanity.



What Is Computer Science? (Cont.)

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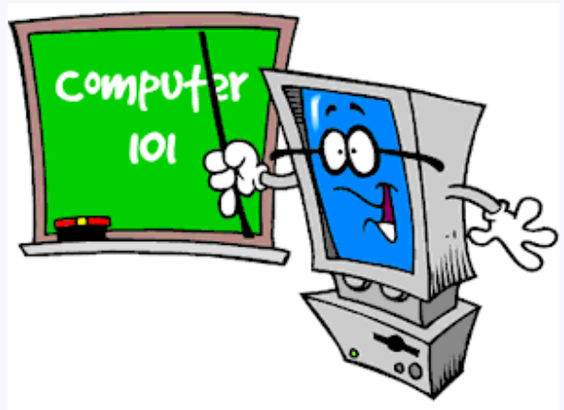

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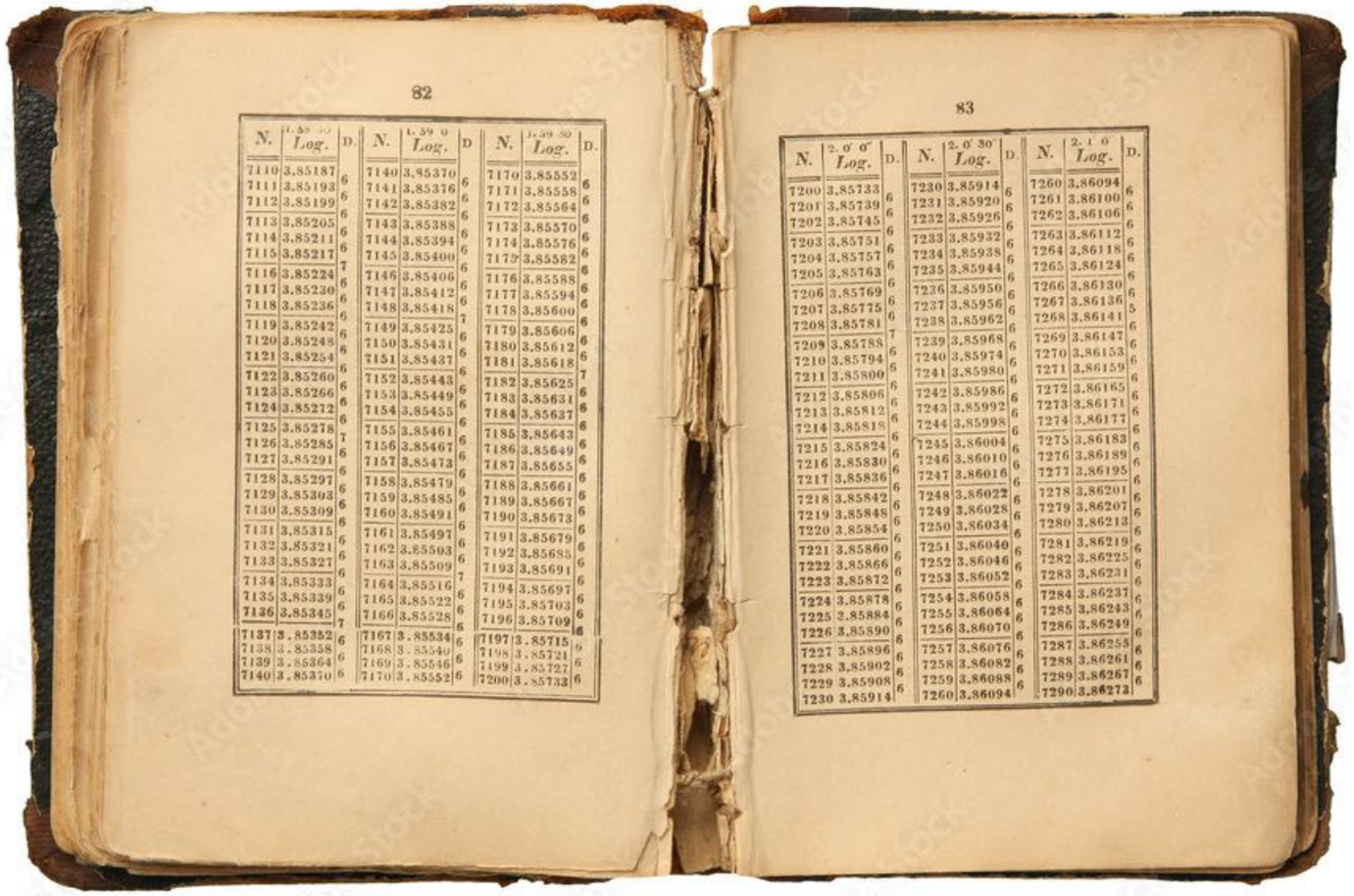
The First Computers... Humans

- So, *how do we execute an algorithm?*
  - The original computer hardware were... human!
    - "Computers" were a job title even up until the 1970s. (Watch "Hidden Figures")

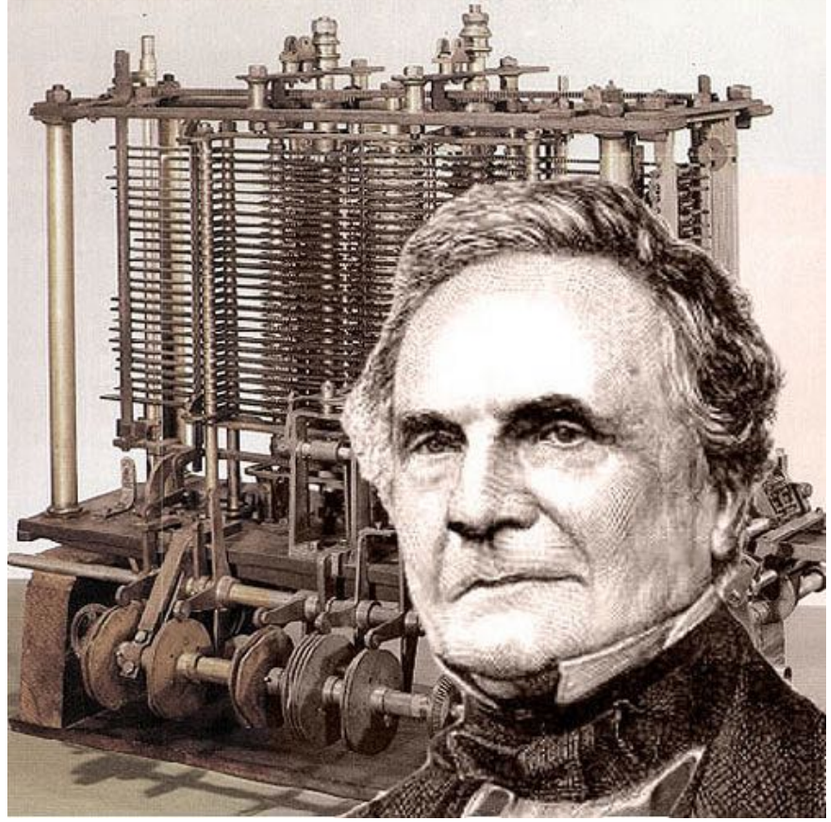
1700s - 1800s: Origins of Computing

- Importance of data tables
  - Used for engineering, studying astronomy, ...
  - Calculations were done by hand. Lacked precision and accuracy

Example: Table of Logarithms

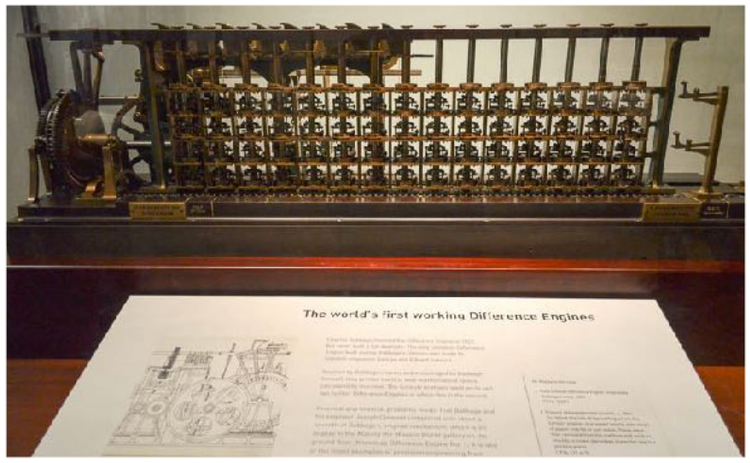


Charles Babbage



Early Computers: The Difference Engine

- Charles Babbage (1791-1871) and Ada Lovelace (1815-1852)
  - Invented the Difference Engine, a mechanical calculator (~1820s)
  - Watch: Calculating Ada documentary (11:00-13:20 minute mark)



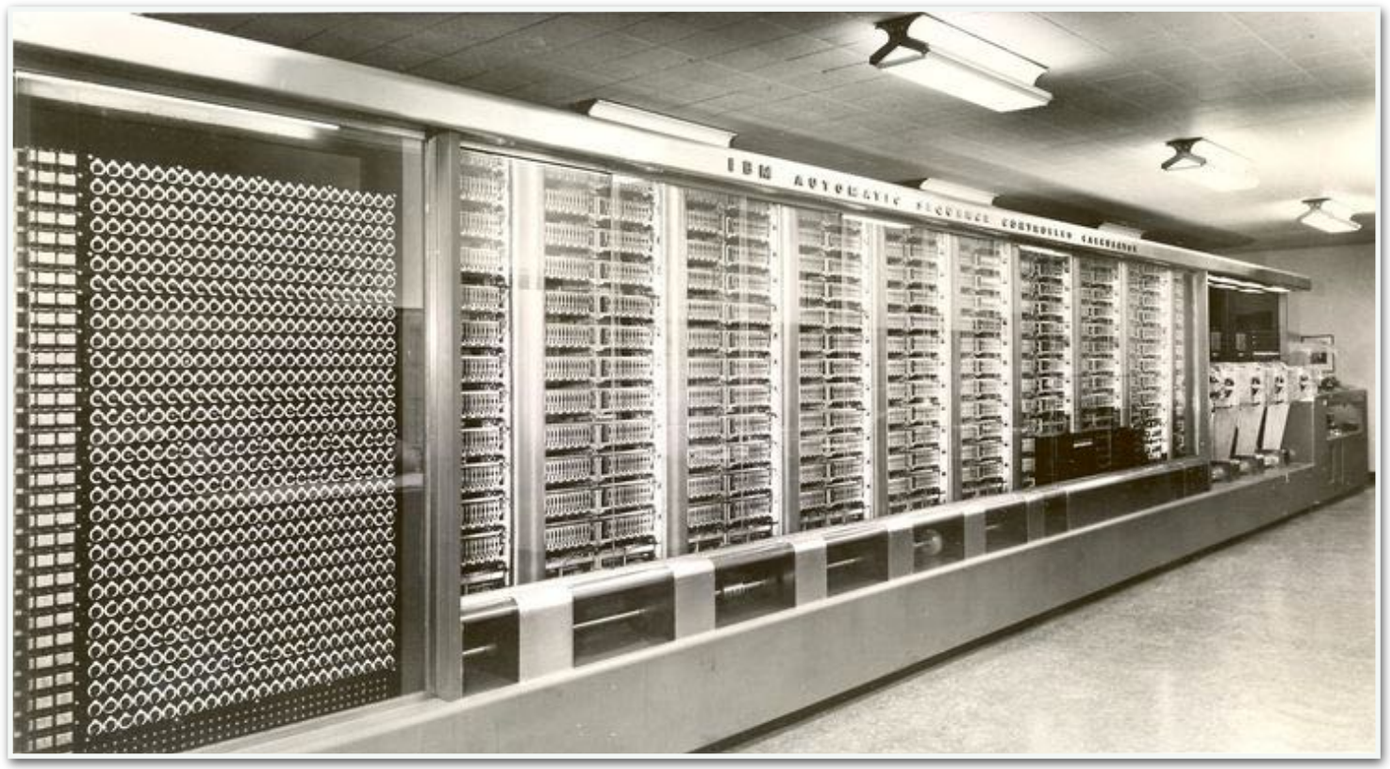
Portion of the Difference Engine
Science Museum in London

Ada Lovelace:
Published the first ever program!
(For the Difference Engine's successor - Analytical Engine)

Harvard IBM Mark I (1944)

- First fully-automatic, *electro-mechanical* general-purpose computer
  - 16m x 2.5m x 2.5m, weighed 5 tons (5000 kg)
  - 3 adds/subtracts per sec; 1 multiplication in 6 secs
  - Fully programmable!
    - Stopped and waited for "go" signal between operations.
  - No OS, programs on tape fed by humans

- *"Sounded like a room full of people knitting."*



1940s: Harvard IBM Mark I (1944)

- Harvard Mark I programming team was led by **Grace Murray Hopper**
  - Professor of Mathematics @ Vassar College
  - Then, as a US Naval Officer, became the first principle programmer of the Mark I

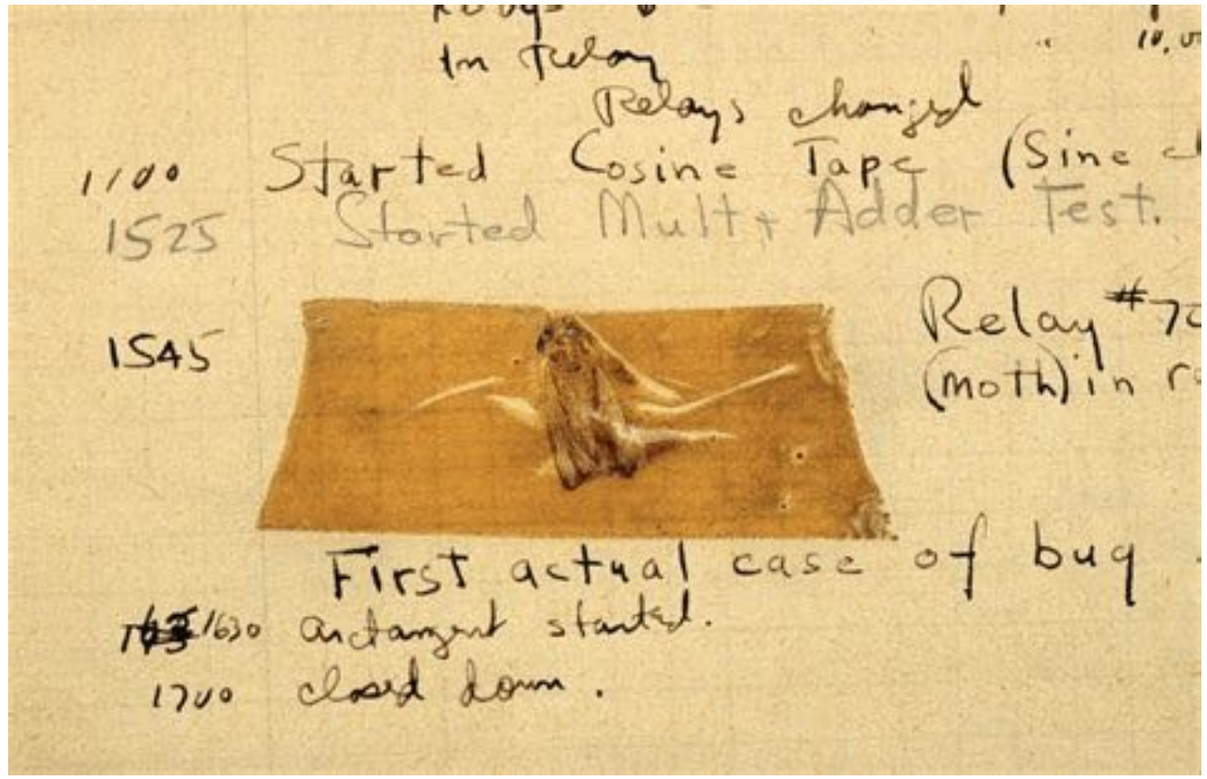
On the Harvard Mark I:

"[it was] the first machine that was built that was supposed to assist the power of man's brain instead of the strength of his arms."

Grace Murray Hopper

Aside: Etymology of Common Terms

- The term "bug" had been already used in the 1800s to describe flaws in electrical systems.
  - An actual bug (a moth) discovered in Harvard Mark II
  - It did actually cause a mechanical issue in a relay
- "Debugging" was coined under Hopper.



"First actual case of bug being found"

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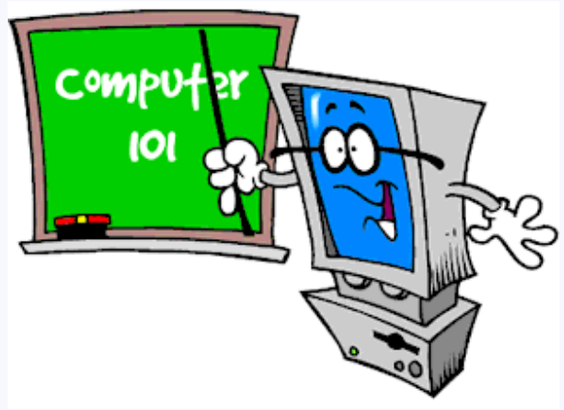


Definition from: Schneider and Gersting. An Invitation to Computer Science.

"The computer is an extremely fast moron. It will, at the speed of light, do exactly what it is told to do--no more, no less."

- Dr. Grace Murray Hopper
  CS Pioneer

Linguistic Realizations of Algorithms

- Let's unpack the quote: "The computer is an extremely fast moron"
- **"extremely fast** moron**"**
  - Today's home computers can do trillions of operations per second!
  - The fastest computer to date (2023) is the *Frontier Supercomputer*
  - At its peak, 1.679 quintillion "primitive operations" per second!
  - https://www.top500.org/

Linguistic Realizations of Algorithms (2)

- Let's unpack the quote: "The computer is an extremely fast moron"

- "extremely fast **moron**"
  - Computers lack *insight*
  - Also, you must tell it what to do *in great detail*, and instructions must be ***very primitive***

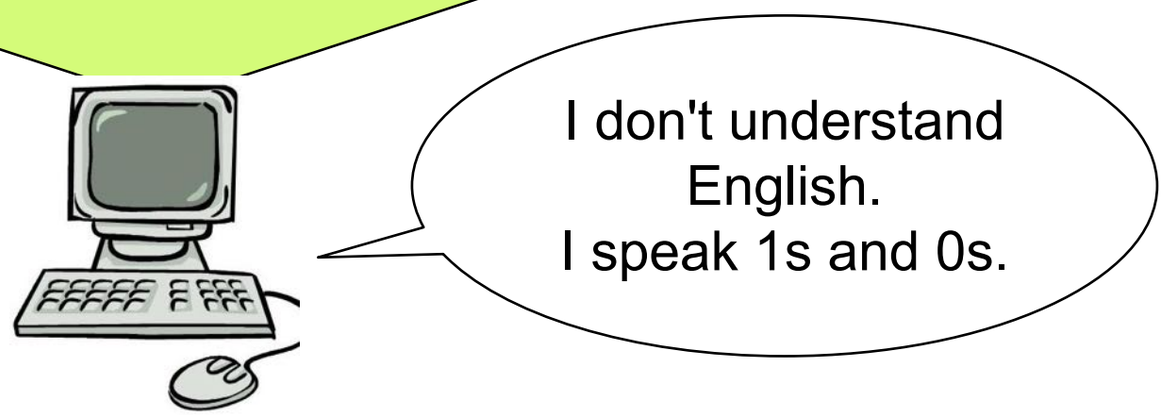
This is what makes programming both frustrating and super rewarding!

Linguistic Realizations of Algorithms (3)

- Just how *primitive* must these instructions be to a computer?

- Consider this: Compute `D = A + (B - 4 * C)`

Instructions to do D = A + (B - 4 * C):
LOAD Contents of A
LOAD Contents of B
LOAD Contents of C
MULT C and 4 and **STORE** in TMP
SUB TMP from B and **STORE** in TMP2
ADD A to TMP2 and **STORE** in D



Even this is not primitive enough!

Linguistic Realizations of Algorithms (4)

- Just how *primitive* must these instructions be to a computer?

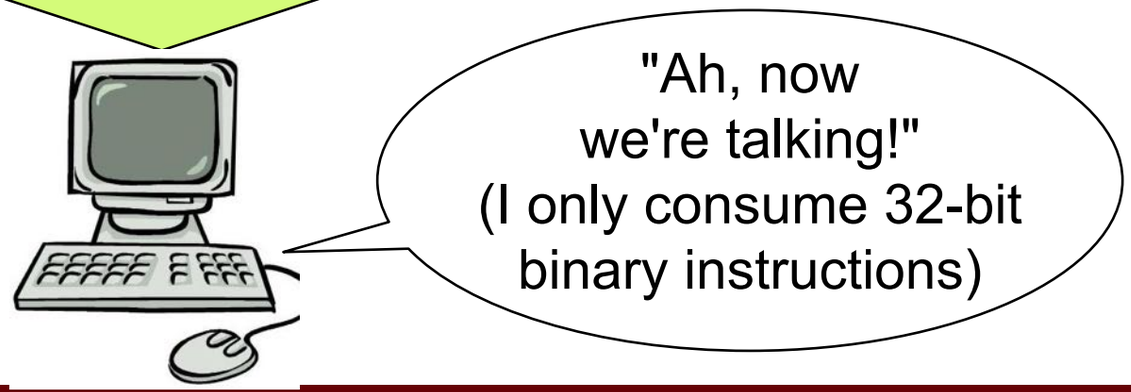
- Consider this: Compute `D = A + (B - 4 * C)`

Instructions to do D = A + (B - 4 * C):

```
01010101110111011001010101000101
01010111011101100101010100010101
01010101110110010101010001010101
01110111011001010101000101010101
11011101100101010100010101010111
01110110010101010001010101011101
```

What each sequence means

⟷	**LOAD**	Contents of A
⟷	**LOAD**	Contents of B
⟷	**LOAD**	Contents of C
⟷	**MULTIPLY**	C and 4 and store in TMP
⟷	**SUB**	TMP from B and store in TMP2
⟷	**ADD**	A to TMP2 and store in D



Linguistic Realizations of Algorithms (6)

Here's an algorithm for how I can solve this problem.

Algorithm Design

Computer Scientist

Express your algorithm using a programming language.

(Known as "coding" or "programming")

Algorithm
(or code, or program)

Translate to 0s and 1s

(Known as "compiling")

Computer **executes** your algorithm.
Solves problem, or throws error

What Is Computer Science? (Cont.)

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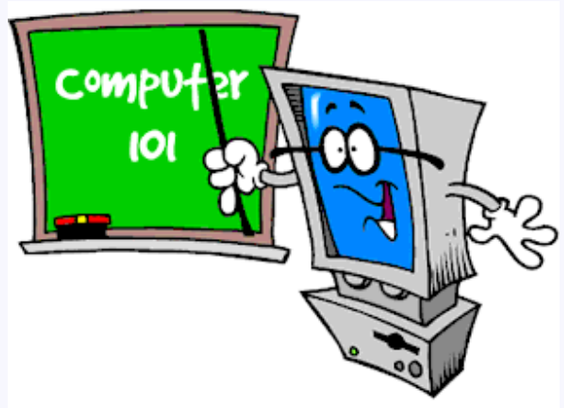

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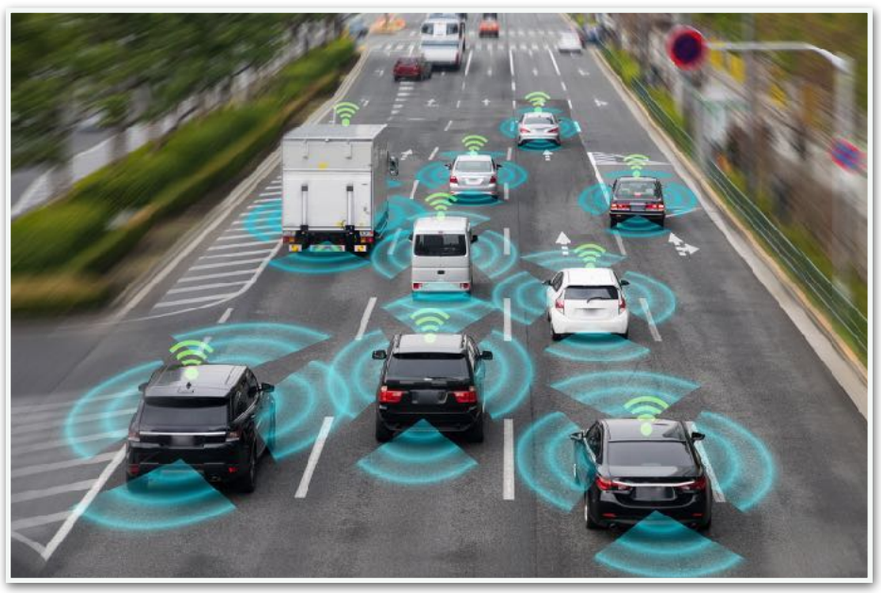
Applications (Software)

- Next "sea-change" in our lifetime?
  - Generative AI: ChatGPT, Dall-E, Midjourney, etc.
  - Smart "things": homes, AI assistants, etc.
  - Social AI: companions, service-oriented
  - Autonomous cars (death of traffic lights?)

- MIT research: https://www.youtube.com/watch?v=kh7X-UKm9kw



Algs: "... and Applications."

- *Computer applications (programs)* start with an idea...
  - Is the idea solvable with algorithms?
    - If not, stop! No computer-based solution is possible.
  - Can the algorithm be processed quickly?
    - If so, program the algorithm, and improve on it over time!
  - Considerations before deploying an algorithm:
    - Technical: What language should I use? What hardware?
    - Ethical: How could my program be misused?
    - Accessibility: Who can have access to my program?
    - Inclusivity: Is my program inclusive of everyone regardless of ethnic background, economic status?
    - **Read: "Weapons of Math Destruction" book**