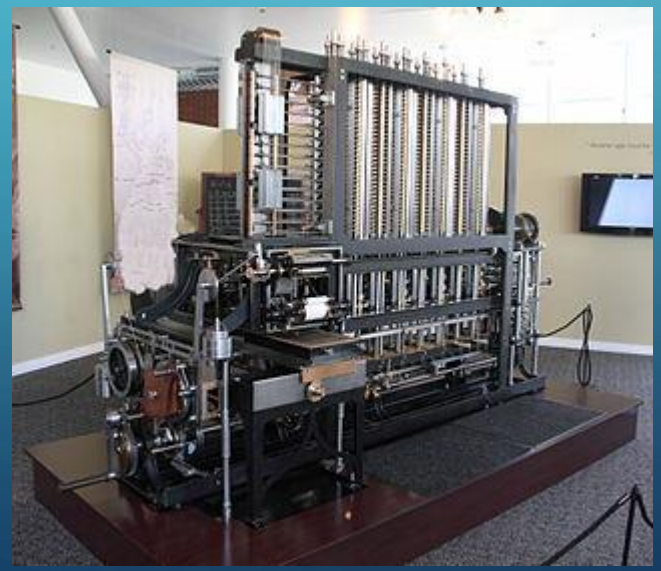
COMPUTER SCIENCE

LESSON 2: TUESDAY SEPTEMBER 12TH, 2017

THE FIRST PROGRAMMER – ADA LOVELACE

- It actually starts with an eccentric named Charles Babbage (1791-1871), who built 2 mechanical “computers”: the Difference Engine and the Analytical Engine
- Ada Lovelace wrote a report on Babbage’s machines, and that’s where it started.

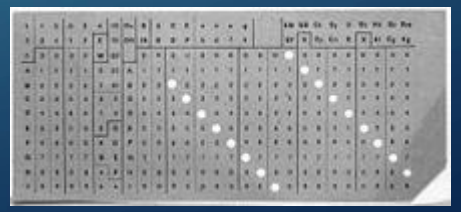


- Ada Lovelace was a computer programmer, but also a fierce mathematician
- She became friends with Charles Babbage, also known as the father of the computer, at 17 and through him studied adv. Math at the University of London
- Ada was asked to translate a report on Babbage's difference machine from French to English. She not only translated, but supplied her own notes – the final report was 3x longer than the original work.
- Ada invented the idea of computer algorithms (pre-set instructions), looping (repeating instructions), and reading letters, symbols, and numbers into a computer (variable types).
- Ada's contributions to the field were not discovered until the 1950s.

FURTHER WORK ON CALCULATING MACHINES – GETTING CLOSER

- William Stanley Jevons built a logic problem solving machine in 1869. It was the first such machine to solve a complicated problem correctly and faster than the problem could be solved by hand. It was nicknamed the “logic piano”

- Hermon Hollerith invented the modern punch card. The purpose of the cards at the time (1890) were to tabulate the responses of the 1890 census, using a machine that he designed himself – the birth of electromechanical tabulating.

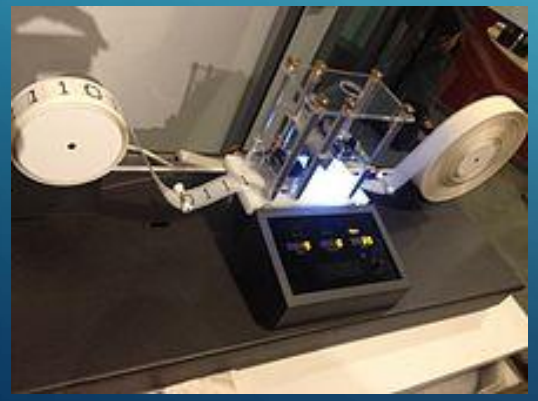


- Leonardo Torres y Quevedo (1852-1936) built electromechanical calculating devices AND was the first to build a machine that could play chess (only simple end games).
  - This is considered the world's first computer game. In 1914, he showcased El Ajedrecista (The Chessplayer) in Paris, complete with mechanical arms to move the pieces. Later the arms were replaced with mechanically movable magnets under the chess board.
  - First of it's kind that did not require human intervention

COMPLETENESS OF MATHEMATICS

- Computers depend on strong mathematics, and their programs/functions thus far require stable mathematical algorithms.
- David Hilbert posed 3 questions to the International Congress of Mathematicians in 1928:
  1. Is mathematics complete? Ie. Can every mathematical statement be proved or disproved?
  2. Is mathematics consistent? Ie. Statements such as "0=1" cannot be proved by valid methods
  3. Is mathematics decidable? Ie. There is a mechanical method that can be applied to every mathematical assertion.
- What would be the consequences of any of these being false?

- Kurt Godel answered the first 2 questions in 1931. He showed that every sufficiently powerful formal system in mathematics is either inconsistent or incomplete – meaning there was a lot more to do in the realm of mathematics. (We still see this today, with many formalisms and theorems being unproven and active fields of research in mathematics.)
- Alan Turing provided a solution to the 3rd question in 1936. Alan Turing's method for proving that mathematics is NOT decidable was to design his own computer – the Turing machine – showing that there were mathematical problems such a mechanical machine could not solve.



While Alan Turing did not build his design, Turing machines have been built since

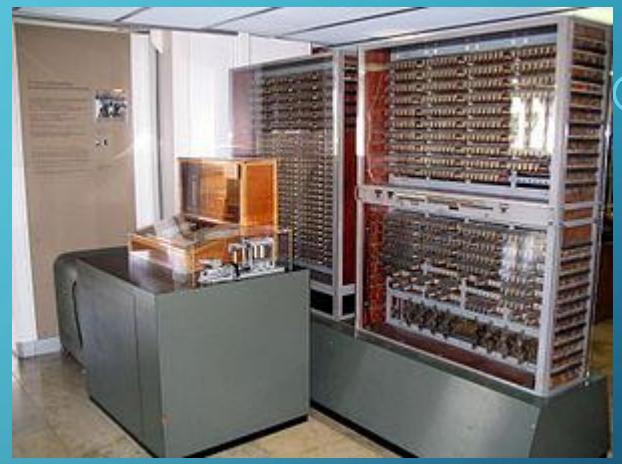
ALAN TURING

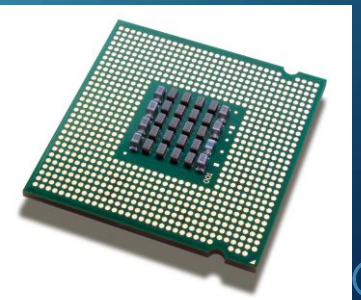
- There's a bit more about Alan Turing that we should cover…
- Alan Turing is considered the founder of computer science and artificial intelligence, a revolutionary code-breaker, and a visionary who perished before his time in a cruel fashion.
- The first step was the Turing machine, which provided a formalism for algorithms and modern computation. The Turing Machine can be considered a general purpose computer by today's standards.
- Of particular note, during WWII he devised a number of techniques for speeding up breaking of German ciphers including an electromechanical machine that could find the appropriate settings for the Enigma Machine. He played a pivotal role in the Allies victory over Nazi Germany, effectively shortening the war by 2 years.

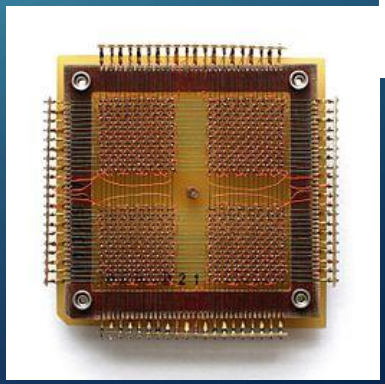
WARTIME = STEM ADVANCEMENT (UNFORTUNATELY)

- Howard H Aiken and IBM (1944), spurred by the need for ballistics calculations, invented the first general purpose electronic digital computer, the Mark I.
- As we saw with Alan Turing, the need for breaking encrypted enemy communications lead to many breakthroughs (Enigma, Colossus).
- ENIAC – general purpose electronic computer for artillery calculations – was finished in 1946.

- First program controlled calculator, the Z3, was invented in 1941 by Konrad Zuse. This makes his invention the first programmable computer, a functional program-controlled **Turing-complete** computer.
- Invention of the transistor in 1947 lead to the microprocessor revolution. The inventors, John Bardeen and Walkter Brattain, received the 1956 Nobel Prize in Physics for this invention.
- Magnetic core memory was invented in 1949, and changed how computers could store and use data.







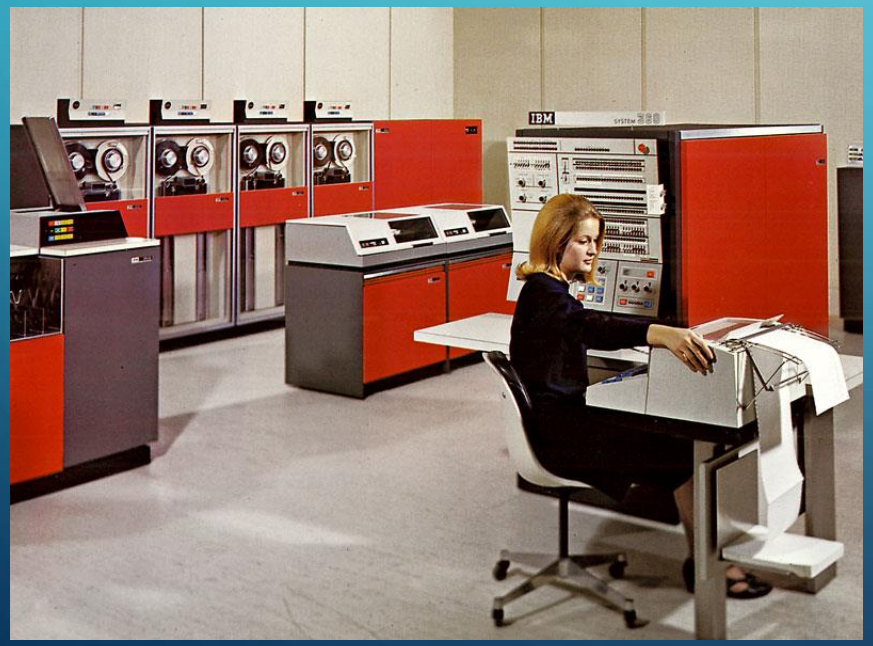
BUGS, LITERAL AND FIGURATIVE

- Compilers weren't always around, even when algorithms and being able to code computers became an option. Compilers compile code, and ensure that it matches standard and leaves no obvious logic flaws. Flaws found by compilers are usually called "bugs".
- The idea of a compiler was invented by Grace Murray Hopper in 1951. Hopper also was the first to find a bug – a literal one. A moth that had gotten into the computer she had been working on.
- The FORTRAN compiler was invented in1957, and other compilers followed suit.
- Alan Turing then introduced the Turing Test, one of the first steps towards the field of artificial intelligence. It stated that if you were conversing with a computer in the next room using a list of pre-determined statements and could not distinguish the entity as human or machine, then it could be determined that the computer is "thinking".

THE BIRTH OF THE FIELD

- While all this real science was happening, there wasn't a distinct field or department or research area for computer science. The name "computer science" was coined by George Forsythe in the 1950s.
- First department founded at Purdue University in 1962. Forsythe got his own CS department at Stanford in 1965.
- First PhD awarded in CS was in December of 1965
- With the field actively recognized and departments popping up at major institutions, innovation and discovery really took off.

- Operating systems (OS) were among the first to advance. IBM designed System/360, categorized by having the same architecture and instruction set.
- ARPAnet, a precursor to the internet, was launched in the late 60s
- New languages such as BASIC were invented
- Invention of computer mouse by Douglas C. Engelbart in 1968
- In particular, the invention of Unix and C were very influential.



SUPERCOMPUTER ERA

- The first supercomputer was shipped in 1976, named CRAY-1. It could perform 160 million operations per second
- Advances in algorithms and complexity also came in leaps and bounds in the 70s, including the public-key cryptosystem RSA

RISE OF THE PERSONAL COMPUTER

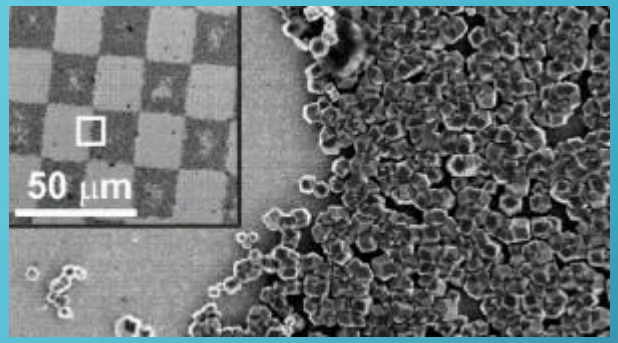
- Computer viruses
  - Not a positive, but an important development in the field! The first computer virus is estimated to be by Leonard Adleman in 1981
- Portable computers
  - So far everything has been clunky and takes up a room! The first portable computer was the Osborn I in 1981.
  - Apple marketed the first Macintosh in 1984
- NSFnet
  - Precursor to the internet, developed by the US National Science Foundation in 1987


OSBORNE


hello.

AND MORE…

- Parallel computing
  - More than 1 process at a time
- Biological computing
  - Using DNA structures for computations and data storage
- Quantum computing
  - Still not quite there, but a cool concept!
- Nano-technology
  - How small can we really go?



LET'S LOOK AT THESE ADVANCEMENTS MORE CLOSELY

HOW DO THEY AFFECT COMPUTER SCIENCE TODAY?

NUMBER SYSTEMS – HOW DO COMPUTERS READ?

- Computers translate everything they read into numbers, this is the simplest form of input. There are a few qualities about a number that are important: the digit, the position of the digit in the number, the base of the number system. Each position in the number system represents (digit)*(base)^(position #)
  - Binary (Base 2, represented as 0,1)
  - Decimal (Base 10, represented as 0,1,2,3,4,5,6,7,8,9)
  - Octal (Base 8, represented as 0,1,2,3,4,5,6,7)
  - Hexadecimal (Base 16, represented as 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F)
  - Can be written as the number rep with a subscript for the base, ie $10_2 = (1*2^1+0*2^0)_{10}$
- Attempt to write the number 12 in binary, octal, and hexadecimal

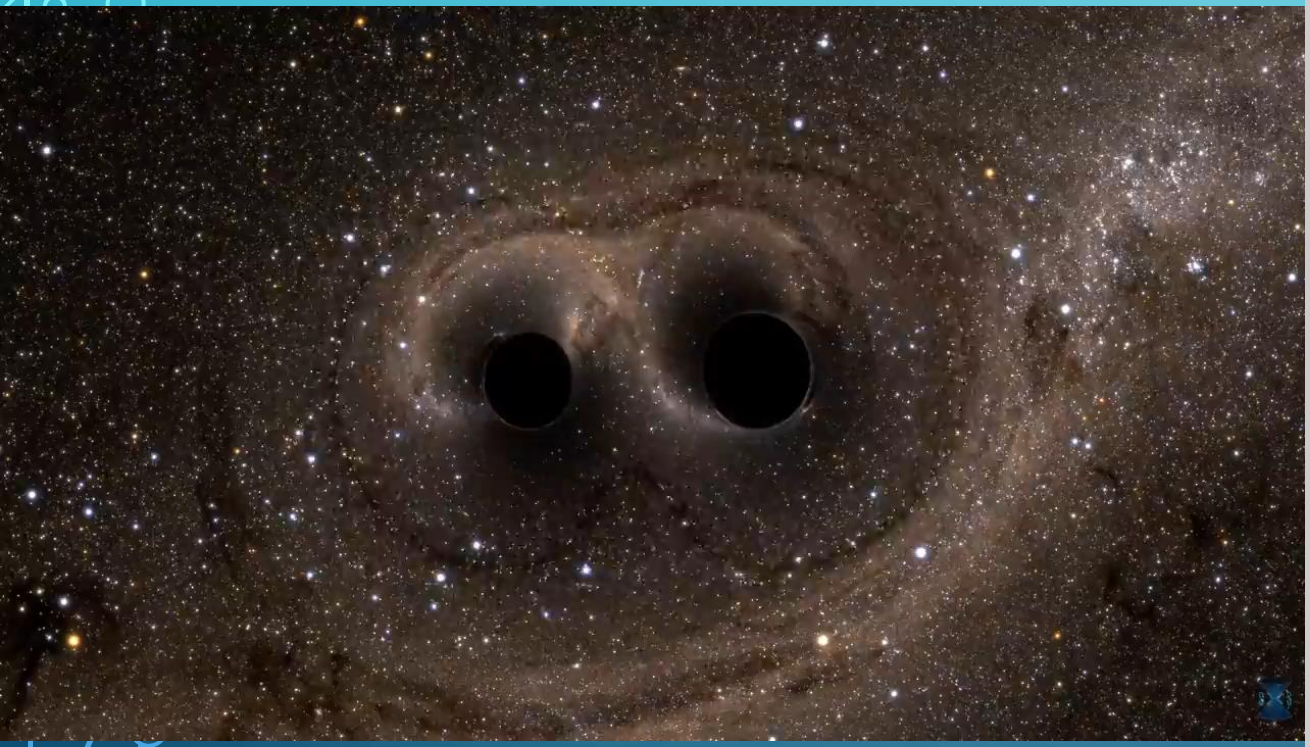
COMPUTER HARDWARE

- Transistors : semiconductors that amplify or switch electronic signals and power. Replaced Vacuum tubes, cut back on space, extra heat generation, and unreliability.
- Micro-processors : an integrated circuit with all the functions of a CPU. Accepts binary input data. Greatly reduced costs and improved efficiency. These are what smart phones and other hand-held devices use!
- Cores and threads: Every computer has cores and threads. A core is a component that DOES a task. Cores can be considered processing units. Each core then can be subdivided into threads, which do individual operations (like adding and subtracting)

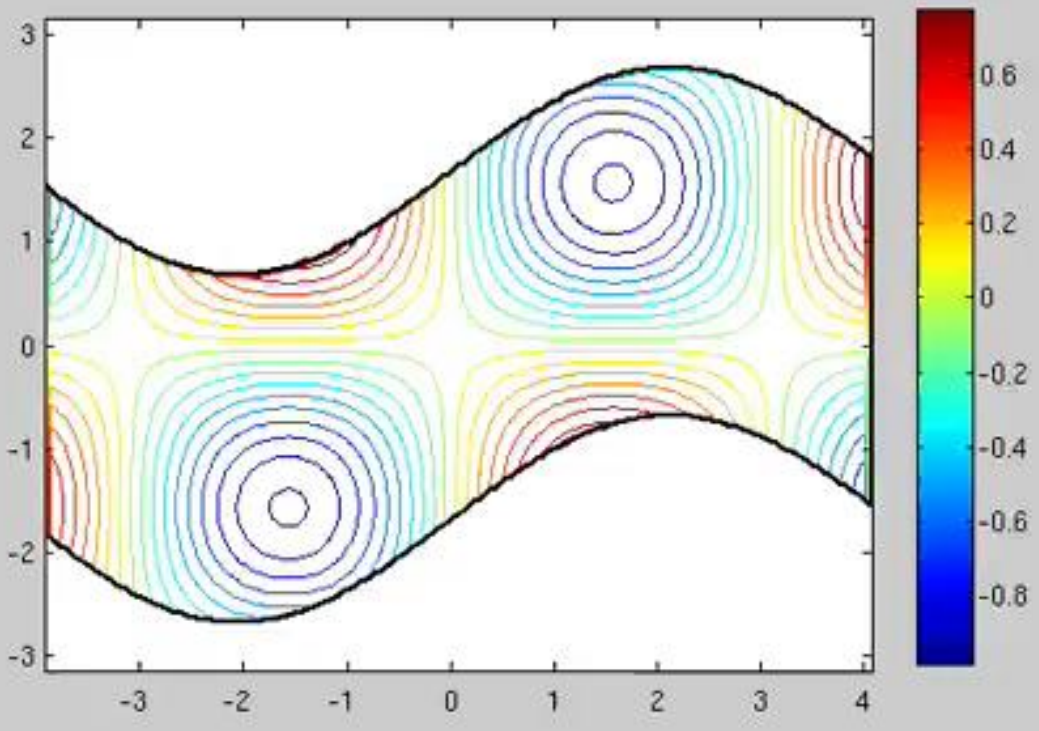
CODING LANGUAGES – THE GIANTS

- Fortran 77, Fortran 90, Fortran 95 – developed by IBM in the 1950s
  - The first, and some argue the best.
  - Was originally built for numeric and scientific computing, and a lot of scientific codes still use Fortran 77 even.
  - Generic programing and high performance, but can be difficult to understand and write effectively.
- C, C++ - “appeared” in 1983, designed by Bjarne Stroustrup
  - General purpose programming, but intended to be object-oriented which is much more intuitive and effective for most programming needs.
  - Bias towards system programming, software infrastructure

C++ and python, with parallel computing



Fortran 90 with parallel computing



ASSIGNMENT 1

- Report based
- Pick 1 major achievement, breakthrough, person, or pivotal moment computer science history. Write a brief report (3-5 pages = 2000-3750 words) on the circumstances/background of the person or event and why it/they are/were important to the field. Remember to include the proper format for a report and have reputable sources!
- Due by Sunday Sept 17th 11:59pm via email submission to woodford@cita.utoronto.ca.

REFERENCES AND LINKS

- Based on material from:
  - U of waterloo CS195 lecture notes : https://cs.uwaterloo.ca/~shallit/Courses/134/history.html
  - https://www.biography.com/people/ada-lovelace-20825323
  - http://www.eingang.org/Lecture/
  - http://www.turing.org.uk/index.html
  - http://www.computerhistory.org/timeline/1984/
  - https://www.extremetech.com/extreme/232190-how-mits-new-biological-computer-works-and-what-it-could-do-in-the-future
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  - https://www.researchgate.net/publication/291718744_Performance_Evaluation_of_Hybrid_Parallel_Computing_for_WRF_Model_with_CUDA_and_OpenMP