

# CM10194 Computer Systems Architecture I

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#### Summary

#### In this lecture:

- Computer Science?
- Computer Architecture
  - What's in it, why is it important?
- Some historical perspective

#### What is Computer Science?

#### The study of

- What problems can be solved by computation
- How to solve these problems
- What design choices lead to effective solutions
- The study of the principles and use of computers.
- •

Computer science is a discipline that spans theory and practice.

- Graphics/Visual Computing
- Artificial intelligence
- Programming Languages
- Software Engineering
- Networking
- Theory
- Human-Computer Interaction
- Computer architecture



That's us  $\odot$  - but why is it important?

Python

C/C++, Haskell, Rust...

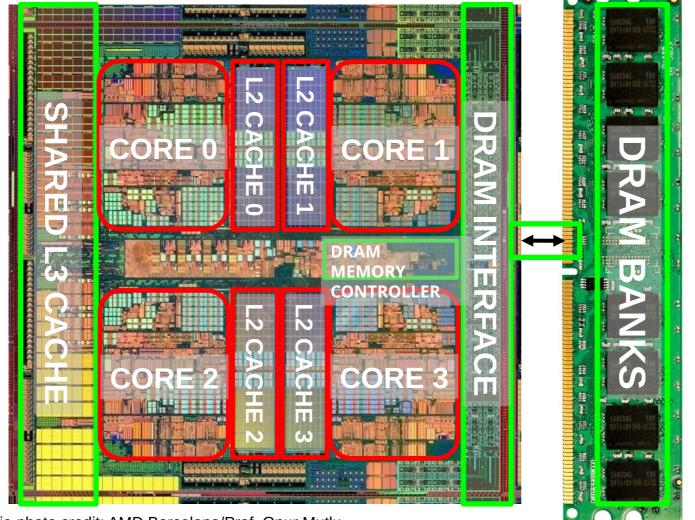
Java

• ...

Several possible answers. (but I like these ones)

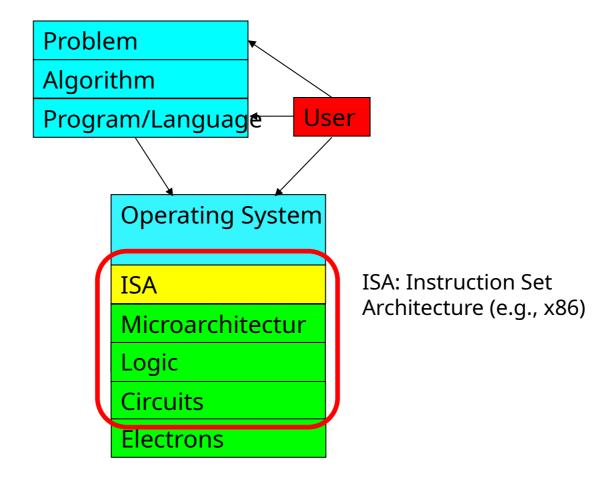
#### Write a program that does 'x' ..... using this:

Does it help if I tell you it is a multi-core system?



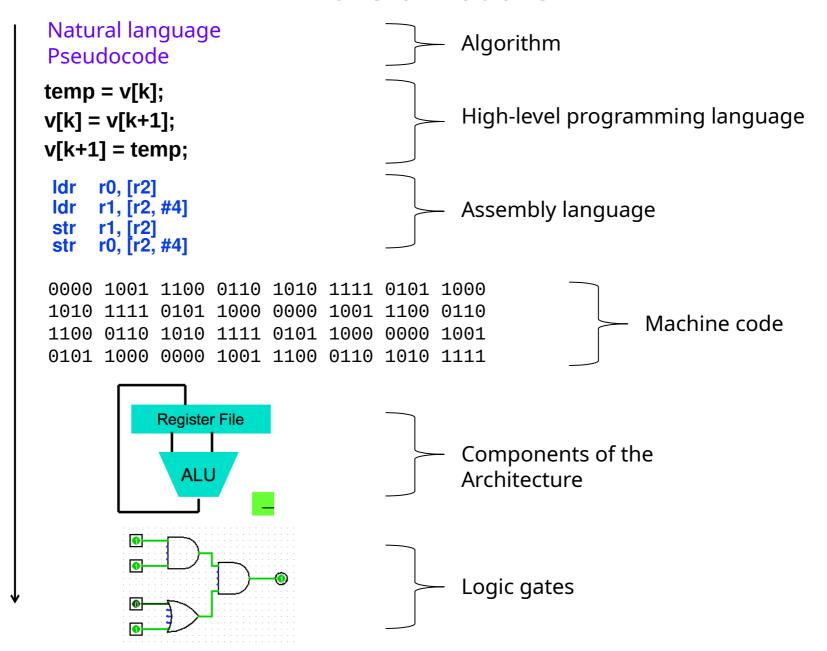
Tough, isn't it? We need something between you (user) and this chip

#### **Abstractions**



<sup>\*</sup>Diagram credit: Prof. Onur Mutlu

#### **Transformations**



#### Architecture:

# The art and science of designing structures.

In this course, we will study the architecture of basic computing systems.

Any idea where the word "computer" comes from?

Used to be "a person performing mathematical calculations"



Radhanath Sikdar (1813 -1870) - an Indian mathematician, an early "computer".

The term "computer", in use from the early 17th century (the first known written reference dates from 1613), meant "one who computes": a person performing mathematical calculations.

#### A calculating device?





Reconstructio n

The Antikythera Device (100BC)

An ancient analogue "computer" designed to calculate astronomical positions (video: <a href="https://goo.gl/Lvh2St">https://goo.gl/Lvh2St</a> and <a href="https://www.youtube.com/watch?v=MqhuAnySPZ0">https://goo.gl/Lvh2St</a> and <a href="https://www.youtube.com/watch?v=MqhuAnySPZ0">https://www.youtube.com/watch?v=MqhuAnySPZ0</a>)

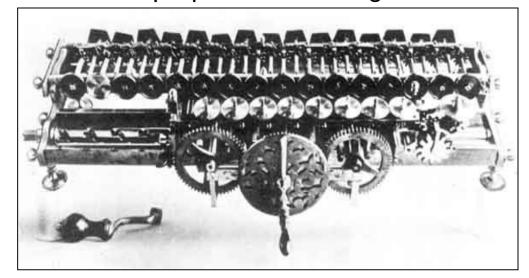
#### A device for numerical calculation?



The "Pascaline": 17th century (by Blaise Pascal) this calculating machine could **add and subtract** two numbers directly and **multiply and divide by repetition**. <a href="https://www.youtube.com/watch?v=3h71HAJWnVU">https://www.youtube.com/watch?v=3h71HAJWnVU</a>

Curiosity: in the 1970s, Niklaus Wirth named a programming language in homage to Blaise Pascal.

#### A multi-purpose calculating device?





Replica of a late model

Leibniz' engine (aka Stepped Reckoner) – multiplication and division (end of 17th century) (
<a href="https://www.youtube.com/watch?v=aWDWiQHOCHw">https://www.youtube.com/watch?v=aWDWiQHOCHw</a>)

A general purpose computing device?

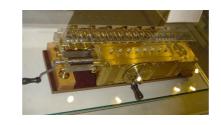


De Colmar's Arithmometer (1820) – 1<sup>st</sup> commercially successful mechanical calculator Key player in the move from human computers to calculating machines that took place during the second half of the 19th century See it in action: <u>http://www.youtube.com/watch?v=v6niUVf0dyQ</u>

#### What is a **modern** computer?









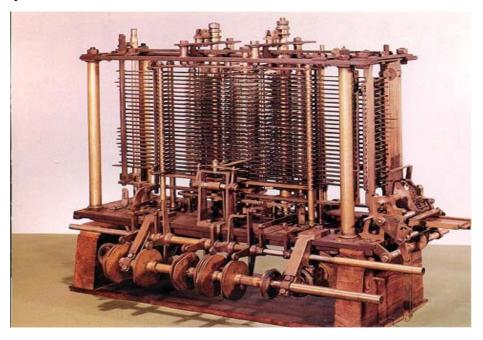
These devices were successful in aiding or replacing human computers.

However they are not consider computers in the modern use of the word.

So then what's consider the first modern computer?

#### What is a modern computer?

A programmable device?



### Charles Babbage's Analytical Engine (designed 1837)

First design of a **general-purpose programmable computer** that could be described in modern terms as Turing-complete (you'll learn in year 2 that it can be used to simulate a Turing-machine).

Babbage was never able to complete construction of any of his machines due to conflicts with his chief engineer and inadequate funding

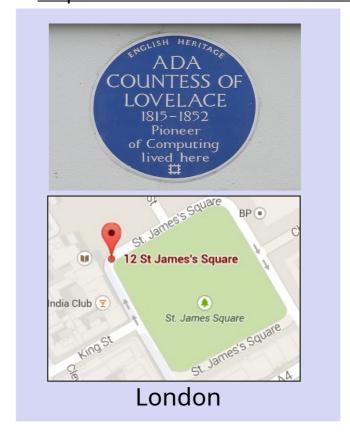
Watch: <a href="http://www.youtube.com/watch?v=QVxbNZWLP60">http://www.youtube.com/watch?v=QVxbNZWLP60</a> (from 3min32s)

#### Ada Lovelace - first world's programmer (Babbage's Analytical Engine)



http://psychclassics.yorku.ca/Lovelace/menabrea.htm

(1843: you can see the notes she wrote together with her translation of a talk given by Babbage) Lovelace Colloquium:
Encouraging Women in Software
Usually around Easter time
<a href="https://bcswomenlovelace.bcs.org/">https://bcswomenlovelace.bcs.org/</a>



The second Tuesday of every October marks Ada Lovelace Day

#### Ada Lovelace - first world's programmer (Babbage's Analytical Engine)





https://learningonscreen.ac.u k/ondemand/index.php/prog/ 0ADD2C3F?bcast=129909817

An abstract machine?
A set of instructions?



Alan Turing 1936

Turing Machine – theory of computation

A. M. TURING

[Nov. 12,

ON COMPUTABLE NUMBERS, WITH AN APPLICATION TO THE ENTSCHEIDUNGSPROBLEM

By A. M. TURING.

[Received 28 May, 1936.—Read 12 November, 1936.]

The "computable" numbers may be described briefly as the real numbers whose expressions as a decimal are calculable by finite means. Although the subject of this paper is ostensibly the computable numbers, it is almost equally easy to define and investigate computable functions of an integral variable or a real or computable variable, computable predicates, and so forth. The fundamental problems involved are, however, the same in each case, and I have chosen the computable numbers for explicit treatment as involving the least cumbrous technique. I hope shortly to give an account of the relations of the computable numbers, functions, and so forth to one another. This will include a development of the theory of functions of a real variable expressed in terms of computable numbers. According to my definition, a number is computable if its decimal can be written down by a machine.

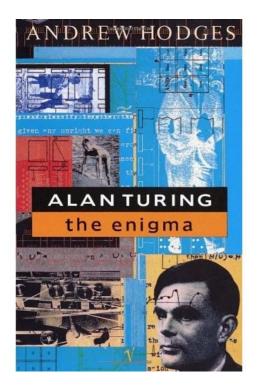
In §§ 9, 10 I give some arguments with the intention of showing that the computable numbers include all numbers which could naturally be regarded as computable. In particular, I show that certain large classes of numbers are computable. They include, for instance, the real parts of all algebraic numbers, the real parts of the zeros of the Bessel functions. the numbers  $\pi_1 e$ , etc. The computable numbers do not, however, include all definable numbers, and an example is given of a definable number which is not computable.

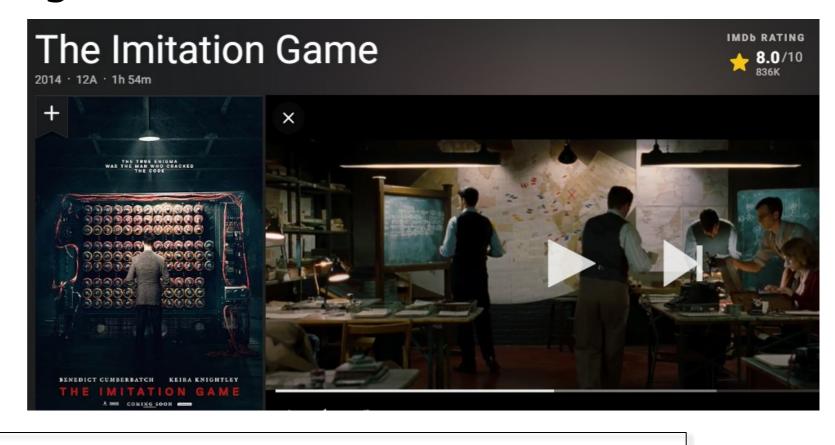
Although the class of computable numbers is so great, and in many ways similar to the class of real numbers, it is nevertheless enumerable. In §8 I examine certain arguments which would seem to prove the contrary. By the correct application of one of these arguments, conclusions are reached which are superficially similar to those of Gödel†. These results

During World War II, Turing worked for the Government Code and Cypher School (GC&CS) at Bletchley Park, Britain's code breaking centre (e.g. Enigma machine)

<sup>†</sup> Gödel, "Über formal unentscheidhare Sätze der Principia Mathematica und verwandter Systeme, I", Monatshefte Math. Phys., 38 (1931), 173-198.

## Alan Turing – book and film





#### **ACM Turing award**

Considered by many the most prestigious award given in Computer Science

https://youtu.be/NoypWbgKLt4

The winners:

http://amturing.acm.org/byyear.cfm

Have a look at some of the winners (e.g. 2017, 2016; then 1997 and 1983)

To be continued...