COMP1002
Computational Thinking and Problem Solving

Lecture 1
Introduction to Computational Thinking

Lecture 1

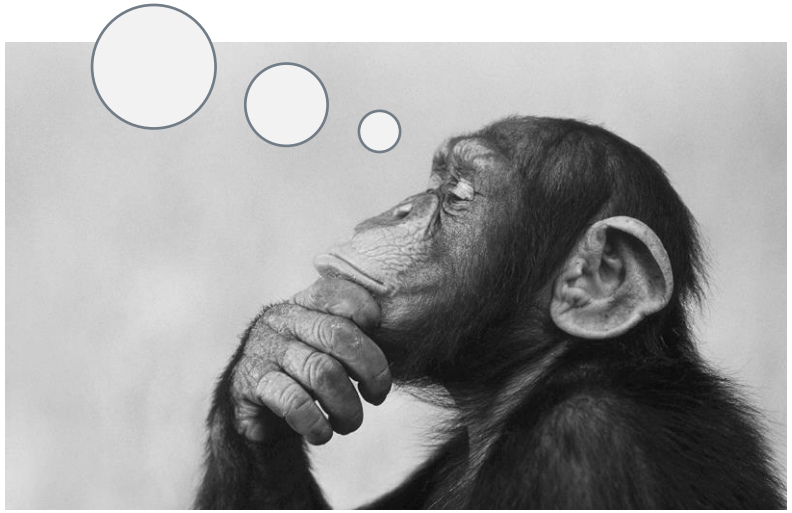
- What is Computational Thinking?
- Why Computer Science?
- Problem Solved vs Have the Problem Solved
- Now and the Future
- Easy or Hard Problem?

What is Computational Thinking?

- Wikipedia
  - Computing is any activity that uses computers to manage, process, and communicate information.
  - It includes development of both hardware and software.
- Association for Computing Machinery (ACM)
  - Discipline of computing is the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application.
  - Fundamental question: what can be efficiently automated?

Computational Thinking

The process of approaching a problem in a systematic manner and creating and expressing a solution such that it can be carried out by a computer.



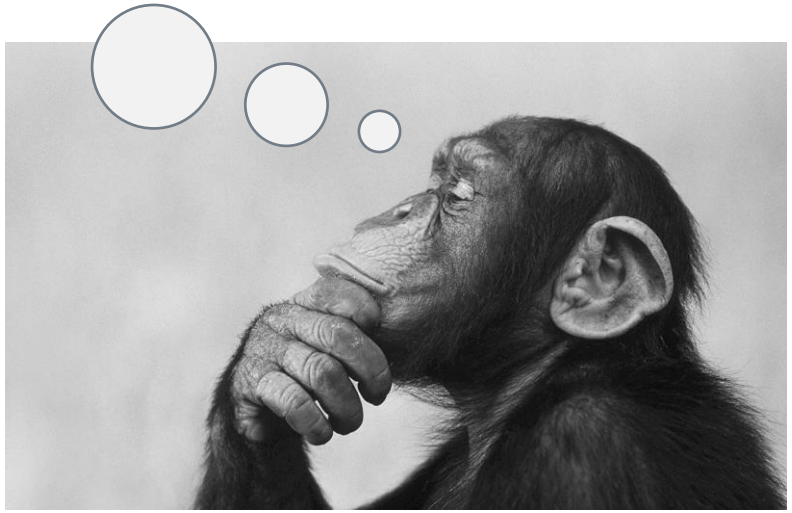
Computational Thinking

- A set of problem-solving methods that involve expressing problems and their solutions in ways that a computer could also execute
  - Need skills and practice to design programs for computers to work for us

- We create computers to think like us. (But,) we also need to think like a computer, why?

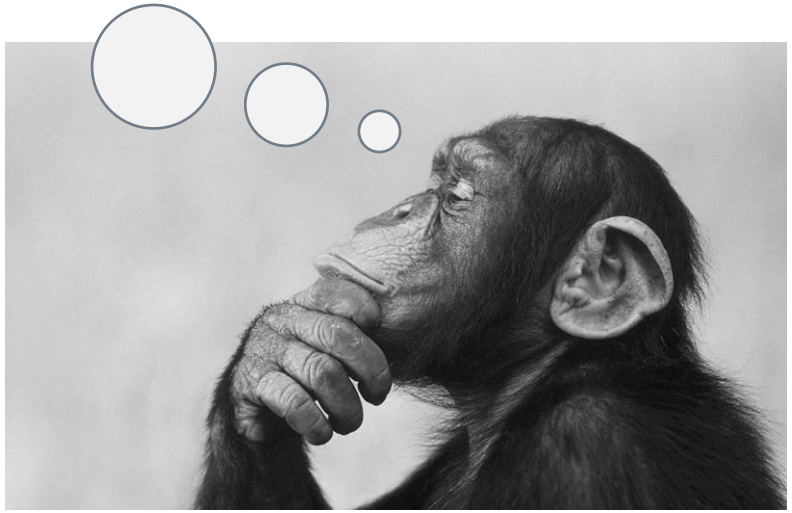
Computational Thinking

The thought processes involved in modeling a situation and specifying the ways an information-processing agent can effectively operate within it to reach an externally specified goal(s).



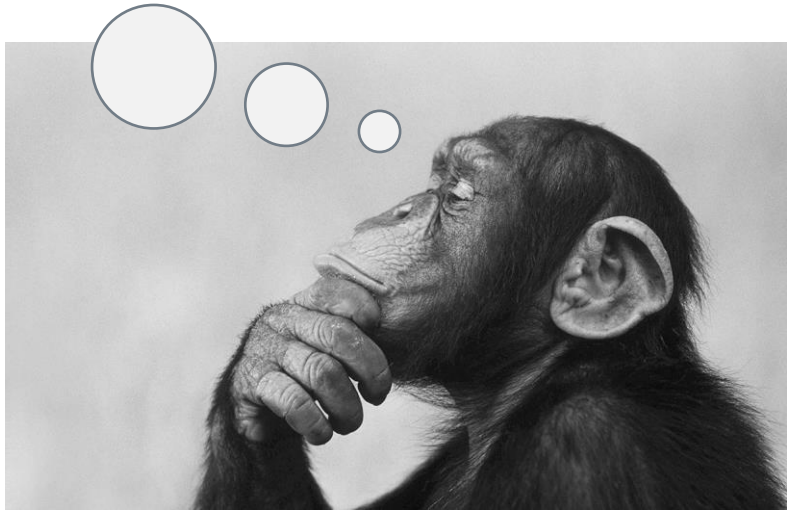
Computational Thinking

Computational thinking refers to the thought processes involved in expressing solutions as computational steps or algorithms that can be carried out by a computer.



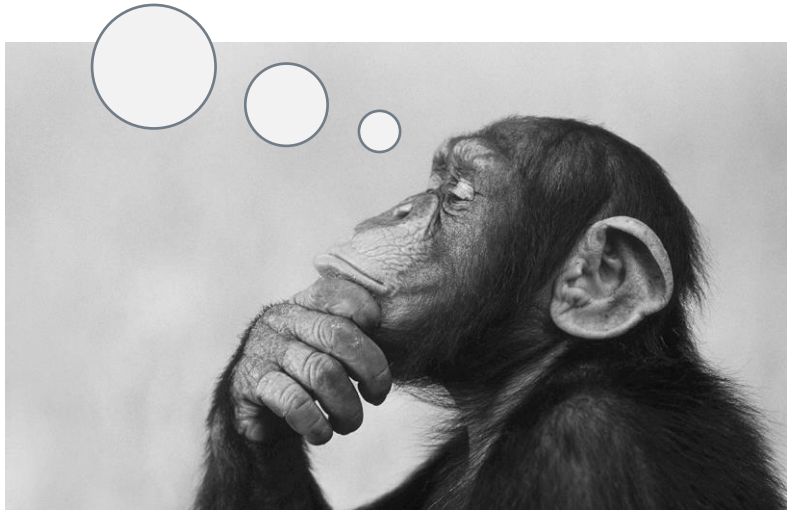
Computational Thinking

The step that comes before programming. It is the process of breaking down a problem into simple enough steps that even a computer would understand.



Computational Thinking

Does it imply a computer to be smart or dumb?



Computational Thinking

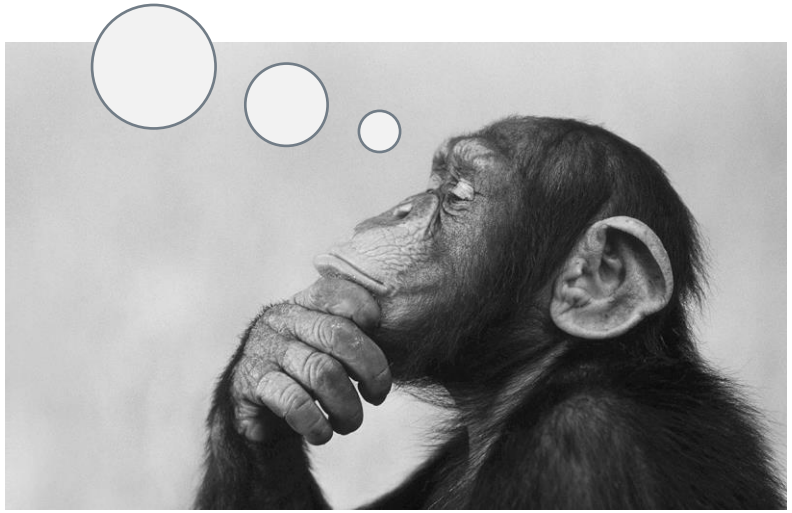
- Computer Science?
- From Theories to Applications
  - COMP1011: Programming Fundamentals
  - COMP1411: Introduction to Computer Systems
  - COMP2011: Data Structures
  - COMP2021: Object-oriented Programming
  - COMP2421: Computer Organization
  - COMP2423: Operating Systems
  - COMP2322: Computer Networking
  - COMP3334: Computer Systems Security
  - COMP4422: Computer Graphics
  - COMP4432: Machine Learning
  - COMP4434: Big Data Analytics
  - ...and more

BSc (Hons) Scheme in Computing & AI

- After Year 1, you have to choose one of the following specialisms:
  - Computer Science
  - Enterprise Information Systems
  - Financial Technology and Artificial Intelligence

A Potential Problem

How can you generate a list of random numbers from 0 – 99?



A Possible Solution

Repeat

- Generate first digit 0 to 9 using a 10-faced die
- Generate second digit 0 to 9 using a 10-faced die
- If number already exists, try again
- If number does not exist, write it down on a piece of paper

Until all 100 numbers are generated

Problem solved?

Image source: https://www.tarquingroup.com/10-sided-dice.html

Computational Thinking

- Problem solved
  - There IS a solution and the solution is found
- Have the problem solved
  - There is an EFFECTIVE solution that can be completed within acceptable amount of time

- In this course, we mostly focus on the first matter

Computational Thinking

- Come to be known only in 2006, proposed by Jeannette Wing
  - A fundamental skill for everyone, not just computer scientists
- Three major steps
  - Abstraction: problem formulation
  - Automation: solution expression (programming)
  - Analysis: solution execution and evaluation

Generic Education Goals

- 4 C's
  - Communication
  - Critical thinking
  - Collaboration
  - Creativity
- What is the fifth C?

Why Computer Science?

- A Case Study in US
  - Obama took a bold new initiative in 2016 to “teach all students computer coding”
  - Computer Science for ALL
    - 4 billion USD to teach Computer Science in US Schools
    - Empower all American students with knowledge in Computing
    - Let them gain knowledge in computer science from kindergarten through high school
- Hong Kong is also promoting STEM education in recent years
  - https://www.edb.gov.hk/attachment/en/curriculum-development/renewal/STEM%20Education%20Report_Eng.pdf

Why Computer Science?

- **Computer has become a necessary tool for most people.**
- Computational thinking will be a fundamental skill used by everyone in the world in the middle of the 21st century" (Jeannette M. Wing)
- "Everybody in the country should learn how to program a computer… Because it teaches you how to think" (Steve Jobs)
- Computer literacy has become essentially for everyday life, especially facing cyber attacks.
- Computer knowledge is essential for many many disciplines.

What is Computer Science?

- The study of the theory, experimentation, and engineering that form the basis for the design and use of computers (Wikipedia).
- The study of automating algorithmic processes that scale (Wikipedia).
- The study of computers and computational systems (UMD).
- Posing a problem in such a way that a computer can help us solve it (NCWIT.org).

What is Computer Science?

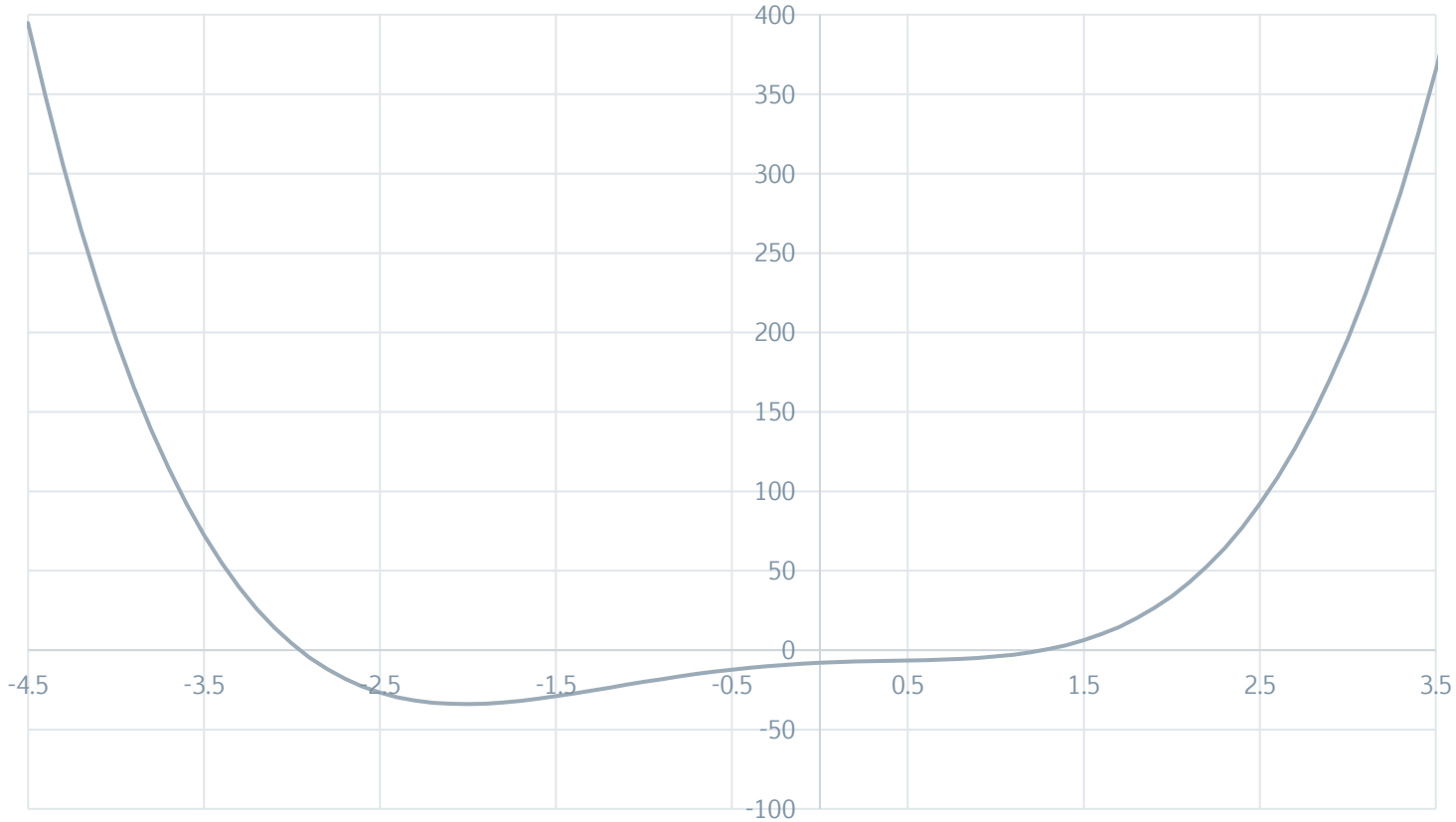
- Understanding computer systems and networks at a deep level (Oxford).
- The study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society (Tucker et. al, 2003).
- Body of knowledge dealing with the design, analysis, implementation, efficiency, and application of processes that transform information (Peter J. Denning).
- The study of computation – what can be computed and how to compute it (Jeannette M. Wing).

Now and The Future

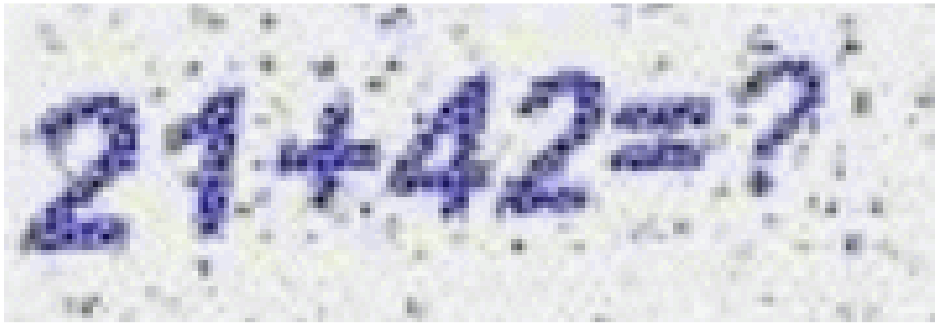
- It has great impacts on other disciplines
  - Biology
  - Chemistry
  - Finance - FinTech
  - Physics
  - Mechanics
  - Musicology
  - Linguistics – NLP
  - Law
  - Fluid dynamics
  - Geosciences
  - Sociology
  - Pharmacology
  - …

Easy or Hard Problem?

- Calculate 12345 * 54321
- Solve $2x^4 + 3x^3 - 6x^2 + 5x - 8 = 0$



Easy or Hard Problem?



Computational Thinking

- Remember
  - Computers are incredibly dumb!
  - But…
    - They are able to repeat the work you ask them to do incredibly fast and accurate
  - And
    - Never feel tired and will not go on to strike
- Computational Thinking
  - Teach the computer to work out the solution of the problem for you, by providing it detailed steps
  - Creating this step-by-step solution (program) needs human intelligence

Computational Thinking

- Make sure that the computer understands what you want
  - Do not assume that it knows what you want
- What is the output for the following?

```
a = 3
b = 5
if (a = b) print(“equal”)
else print(“not equal”)
```

Final Word

- Computational thinking is the process of approaching a problem in a systematic manner and creating and expressing a solution such that it can be carried out by a computer
- Three major steps
  - Abstraction: problem formulation (understand and represent)
  - Automation: solution expression (design steps for program)
  - Analysis: solution execution and evaluation (develop and run program)

Summary

- What is Computational Thinking?
- Why Computer Science?
- Problem Solved vs Having the Problem Solved
- Now and the Future
- Easy or Hard Problem?