Watch 13 minute short film before Wednesday…

# The Beauty and Joy of Computing

**Quest** (first exam) in **in 9 days!!**

## Lecture #4 : Creativity & Abstraction


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### LEARN LANGUAGE FREE!

Luis von Ahn's recent project is Duolingo, which is simultaneously allowing its users to learn a second language free, while also providing a cost-effective way to get documents translated on the web.

### PREVENTING ADDICTION!

Researchers in the UK said that some gamers play up to 90 hrs a session, developing a "pathological" addiction. They say game makers need to do more, to get "sensible gaming"

www.duolingo.com
www.bbc.co.uk/news/uk-wales-south-east-wales-23576035

# Computing is a Creative Activity

- "Creativity and computing are **prominent forces in innovation**; the innovations enabled by computing have had and will continue to have **far-reaching impact**.
- At the same time, **computing facilitates exploration** and the creation of knowledge.
- This course will emphasize these **creative aspects of computing**.



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# Computing enables people…

- …to translate intention into **computational artifacts**.
- A computational artifact is created by human conception using software tools.
- Examples of computational artifacts include
  - digital music, videos, images
  - documents
  - combinations of these. E.g.,
    - infographics
    - presentations
    - web pages.




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# Computing enables people…

- …to **create** digitally!
- Creating…
  - knowledge
  - tools
  - expressions of ideas
  - solutions to problems.
- Creating digitally…
  - requires understanding and using software tools.
  - can be done by…
    - combining and modifying existing artifacts
    - creating new artifacts.

# Collaboration is an essential part…

- …of creating computational artifacts.
- Collaboration facilitates multiple perspectives in developing computational artifacts.
- A computational artifact can reflect collaborative intent.

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# We can analyze computational artifacts…

- …for correctness, functionality, and suitability.
- A computational artifact may have weaknesses, mistakes, or errors depending on the type of artifact.
  - For example, music created by a program may not have an error but may simply be hard to listen to.
- The functionality and suitability (or appropriateness) of a computational artifact may be related to how it is used or perceived.

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# Computing extends traditional forms…

- …of human expression and experience.
- Computer music can be created by synthesizing sounds, by sampling existing music, or by recording and manipulating sounds.
- Creating digital effects, images, and animations has impacted and transformed the movie industry.
- Computing enables creative exploration of real and synthetic phenomena.



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# Programs can be developed…

- …for creative expression or to satisfy personal curiosity.
- A program developed for creative expression or to satisfy personal curiosity may have visual, audible, or tactile results; or the program may affect a computer or system without such results.
- Programs developed for creative expression or to satisfy personal curiosity may be developed with different standards or methods than programs developed for widespread distribution.
- A program or the results of running a program may be shared with others.


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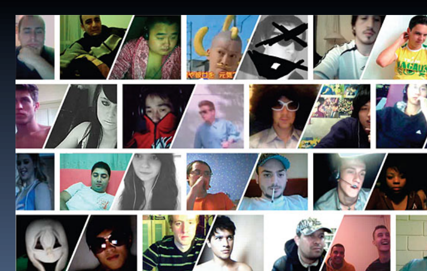
# Programs can be developed…

- …to **solve** problems, **create** new knowledge, or **help** people, organizations, or society.
  - however, the goals may be realized independently of the original purpose of the program.
- **Computer programs** and the results of running the programs have **widespread impact** on individuals, organizations, and society.



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# Numbers: Positional Notation

- Number Base B ⇒ B symbols per digit:
  - Base 10 (Decimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
  - Base 2 (Binary): 0, 1 (In binary digits are called "bits")
  - Base 16 (Hexadecimal): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- Number representation:
  - $d_{31}d_{30} \ldots d_1d_0$ is a 32 digit number
  - value = $d_{31} \times B^{31} + d_{30} \times B^{30} + \ldots + d_1 \times B^1 + d_0 \times B^0$
- Binary 0b11010 $= 1\times2^4 + 1\times2^3 + 0\times2^2 + 1\times2^1 + 0\times2^0$
  $= 16 + 8 + 2$
  $= 26$
- Hex 0x1A $= 1\times16^1 + 10\times16^0$
  $= 16 + 10$
  $= 26$
- One hex digit (four bits) is a "nibble". Two (eight bits) is a "byte" (values 0-255)
- N bits ⇔ at most $2^N$ things

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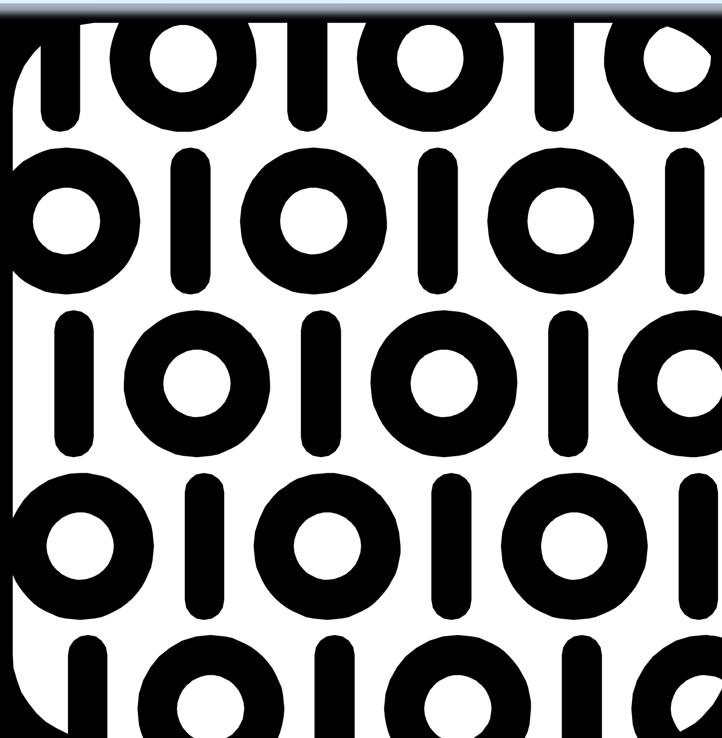
# Abstraction (revisited): Numbers

- **Number bases**, including binary and decimal, are used for reasoning about digital data.
- Bits represent binary data using **base two** digits: zero and one.
- **Hexadecimal**, or **base-16**, is often used in reasoning about data such as colors in images.
- **Different bases help** in reasoning about digital data; digital data is stored in bits.





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# Abstraction (revisited): Digital Data

- A **combination of abstractions** is used to represent digital data.
- At the lowest level **all digital data are represented by bits.**
  - Said another way, bits can represent anything!
- **Bits are grouped** to represent higher-level abstractions including numbers and characters.
  - Logical values? 0 → False, 1 → True
  - Colors? 00 → Red, 01 → Green, 10 → Blue
  - Characters? 00000 → 'a', 00001 → 'b', …
- **Higher-level abstractions** such as Internet protocol (IP) packets, images, and audio files are comprised of groups of bits that represent different parts of the abstractions.



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# Binary Sequences to Represent Data

- A **finite representation** is used to model the infinite mathematical concept of a number.
- In many programming languages the **fixed number of bits** used to represent **integers limits the range** of integer values, and mathematical operations can result in **overflow** or other errors.
- In many programming languages the fixed number of bits used to represent **real numbers** (represented as "floating-point numbers") **limits their range**, and mathematical operations can result in **round-off** and other errors.




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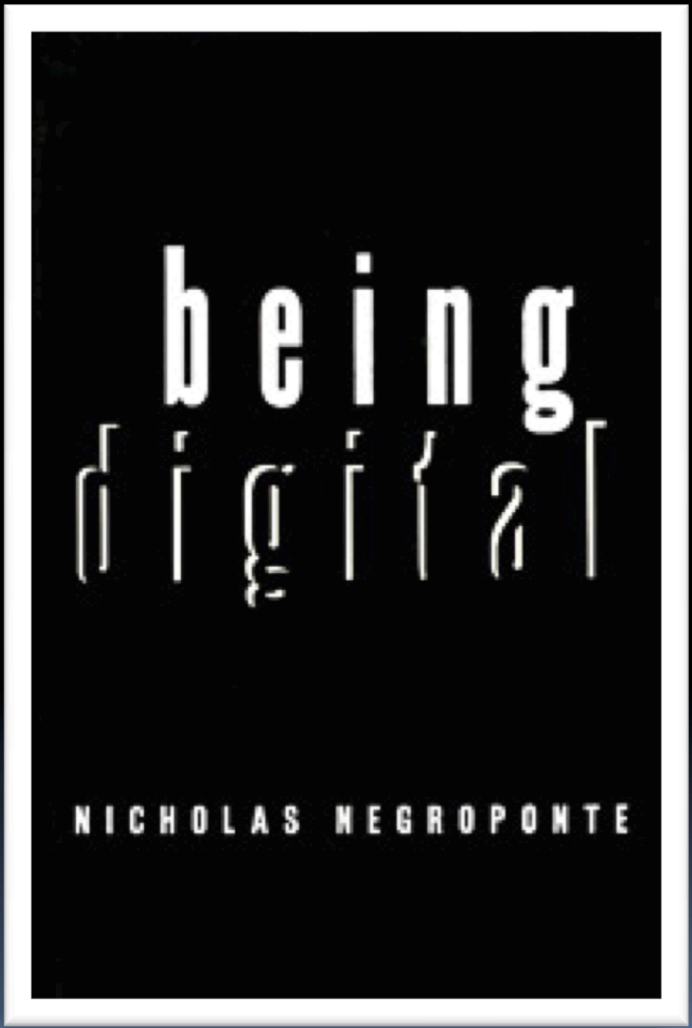
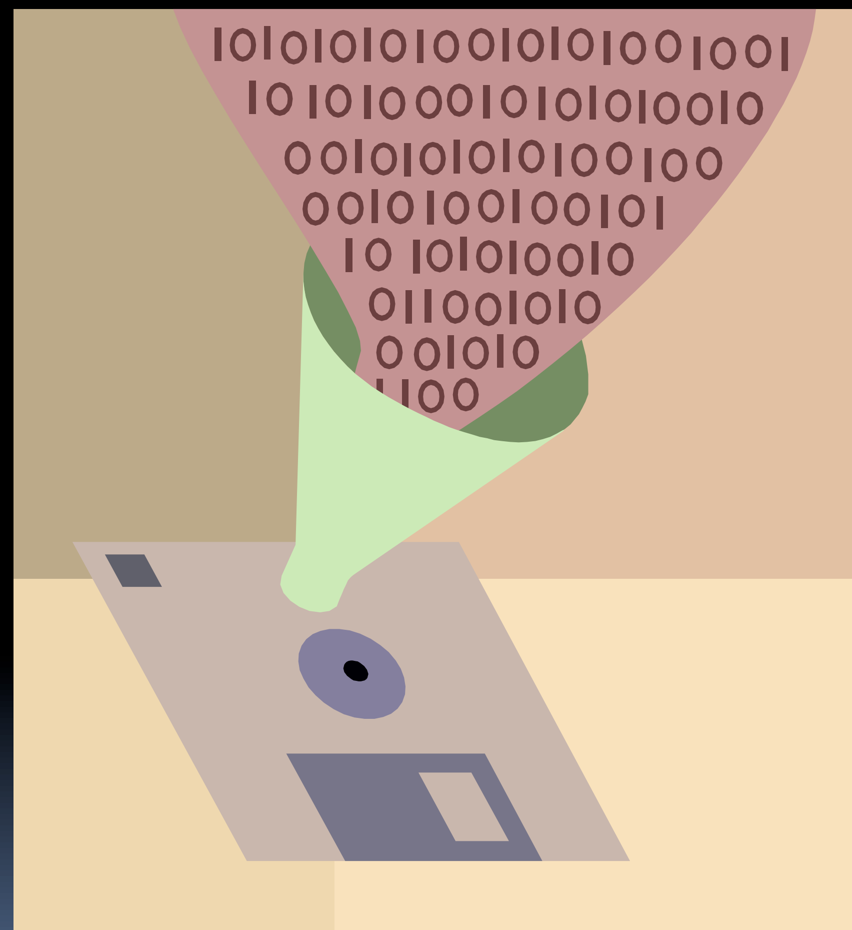
# Interpretation of a Binary Sequence…

- …**depends on how it is used** (e.g., as instruction, number, text, sound, or image).
- The sequence of bits that represents…
  - …an instruction may also represent data processed by that instruction.
  - …a character/letter may also represent a number.
  - …a color in an image may also represent a sound in an audio file.



# SW and HW built on multiple abstractions!

- **Software is built using low- and high-level abstractions…**
  - such as expressions, statements, data types, functions, and libraries.
  - that represent hardware, such as device drivers and game controllers.
- **Hardware is built using low- and high-level abstractions such as chips, memory, and storage.**





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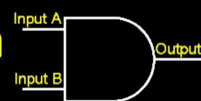
# Binary Data is processed by…

- …physical layers of computing hardware, including gates, chips, and components.
- A **logic gate is a hardware abstraction** that models a Boolean function.


- A **chip is an abstraction** composed of low-level components and circuits that performs a specific function such as memory, CPU, encryption, and more.




- A hardware component can be low level like a transistor or high level like a video card.



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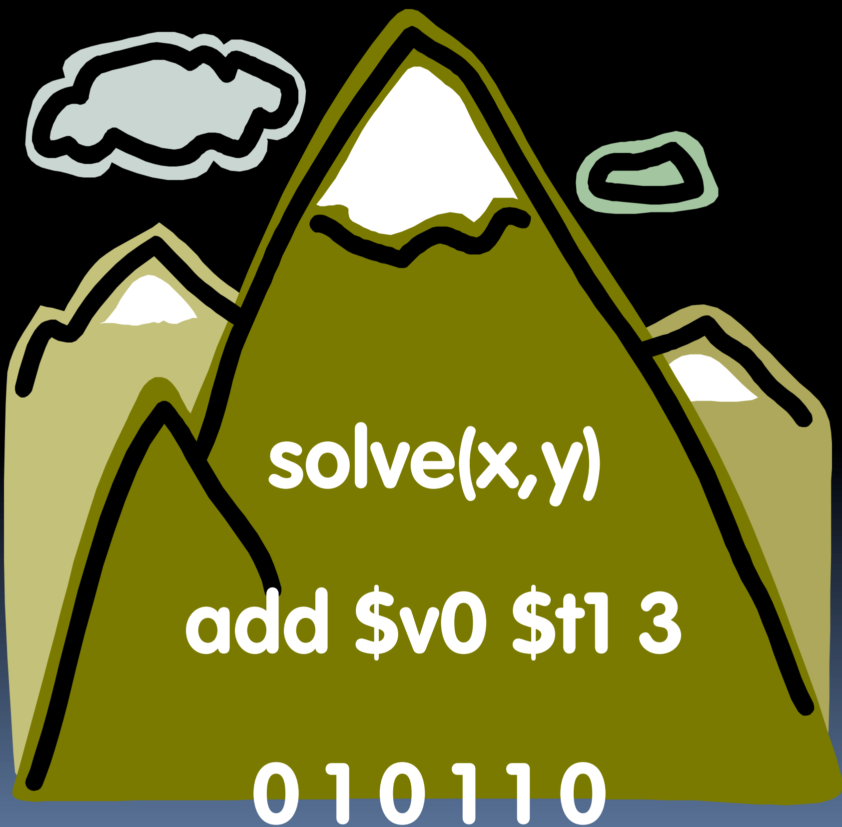
# Programming languages, from low to high level…

- …are used in developing software.
- Low-level programming languages, such as assembly, are closer to the machine level and provide fewer abstractions for the programmer.
- High-level programming languages provide more abstractions for the programmer and are easier for humans to use for reading and writing code.
- Code in a high-level programming language is typically automatically translated into code in a lower-level language to be executed on a computer; this is done by a compiler or an interpreter.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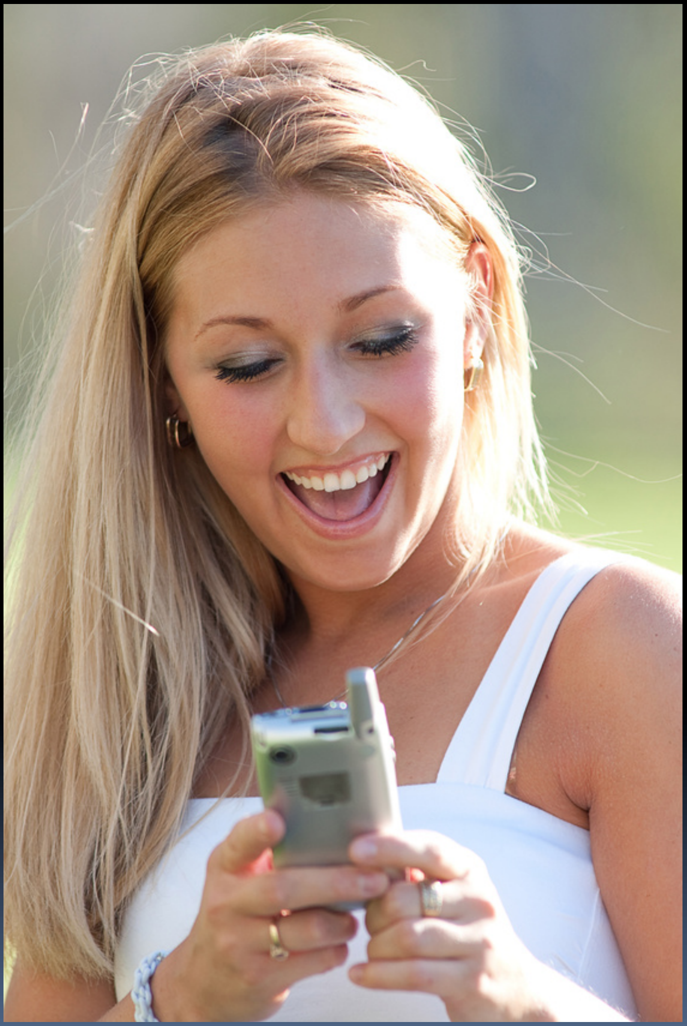
# Abstractions everywhere!

- Applications and systems are designed, developed, and analyzed using levels of hardware, software, and conceptual **abstractions**.
  - E.g., Mobile applications and systems
  - E.g,. Web services (both an application and a system)





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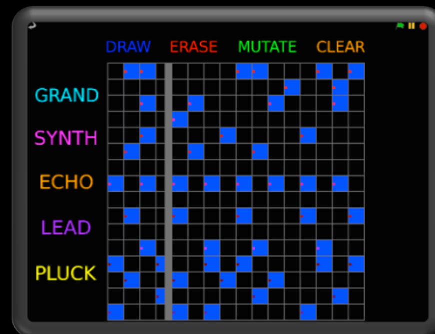
# Summary

- **Creativity**
  - You will create interesting and relevant artifacts with the tools and techniques of computer science.
- **Abstraction**
  - This course will include examples of abstractions used in modeling the world, managing complexity, and communicating with people as well as with machines.
  - You will learn to work with multiple levels of abstraction while engaging with computational problems and systems.

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