CS 115 Lecture 2
Fundamentals of computer science, computers, and programming

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1 September 2015
What is programming?

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- Telling a computer what to do?
  - But every time I click on a button, or press a key, I am telling the computer what to do.
  - That’s not quite what we mean by programming.
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When you do long division or sort a list of names, you are computing.

Computer science is the study of:
▶ What can be computed using step-by-step procedures.
▶ How best to specify these procedures.
▶ How to tell if a procedure is correct, efficient, etc.
▶ How to design procedures to solve real-world problems.

An early computer network, around 1890.

E.C. Pickering’s astronomy lab at Harvard.

Image: Harvard University, Wikipedia article “Harvard Computers”
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Let’s look at one algorithm that is even older than that: Euclid’s greatest common divisor algorithm. One of the oldest algorithms that is still in use. In Euclid’s Elements, written around 300 BCE. Older than long division!

Muhammad Al-Khwarizmi, Persian computer scientist.

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Euclid’s algorithm

Given two numbers $a$ and $b$, their greatest common divisor (GCD) is the largest number that both are divisible by.

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Inputs: two positive integers (whole numbers) $a$ and $b$.

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(Sculpture: J. Durham / Image: Mark A. Wilson, Wikipedia, 2005.)
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- These are the steps to solve a problem.
- A design is like an outline or rough draft for your program.
- Figure out what you’re going to do before you start doing it!
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Let’s say we want to build a dog house.
Design: building a dog house

Let’s say we want to build a dog house. What steps do we need to take?

1. Decide on a location and size for the doghouse.
2. Get materials for the house.
3. Cut a piece of wood for the floor.
4. Cut wood for the four walls.
5. Cut a door into one wall.
6. Assemble walls.
7. Attach walls to the floor.
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- What’s the budget?
Dog house, refined

1. Decide on a location and size for the doghouse.
2. Get materials for the house.
   1. Get lumber.
   2. Get paint.
3. Cut a piece of wood for the floor.
4. Repeat four times:
   1. Cut a piece of wood for a wall.
5. Cut a door into one wall.
6. Attach walls to the floor.
7. Make roof.
   1. Cut two pieces of wood.
   2. Join the pieces at a 90 degree angle.
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- Never finished in his lifetime.
- Finally built in 1991.
- And it worked!

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Stored programs

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Stored programs

- British mathematician Alan Turing described in 1936 a mathematical model:
  - A founder of modern computer science.
  - He realized that you could make a universal machine:
    - It would take as part of its input a description of the program to run.
    - Programs become just another kind of data!
  - John von Neumann developed these ideas further in 1944.
  - Turing later went on to develop the bombe to break WWII encryption.
  - Germany used the Enigma machine to encrypt wartime messages.
  - The bombe figured out which settings the Enigma used each day.
  - 2014 film: The Imitation Game:
    - "The Imitation Game" was his name for what we now call the "Turing test": how can we tell whether a computer is intelligent?
  - A sad end.
  - In 1952, it came out that Turing was gay: illegal at the time.
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Image: Los Alamos National Lab.
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Parts of a modern computer

- RAM: the computer’s “working memory”.
  - “Random Access Memory”

- Secondary storage: hard drives, flash, DVD, ...
  - Persistent: data can be stored for years or decades.
  - Slow (microseconds to milliseconds: < 1/1000 the speed of RAM)
  - Relatively cheap.

- Data must be transferred to RAM before the CPU can use it.

- CPU: Central Processing Unit.
  - Reads instructions from RAM.
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    - 1, 2, 4, 8, 16, 32, 64, 128

- So 01001011 = 1 + 2 + 8 + 64 = 75
- (More about this in chapter 3).
- One byte can represent a number from 0 to 255.
  - Or a single character in ASCII code.

- Kilobyte (kB): $2^{10} = 1024$ bytes (about a page of text)
- Megabyte (MB): $2^{20} \approx 1$ million bytes (1024 kB, a large book)
- A song in MP3 format might take 3 or 4 MB.
- Gigabyte (GB): $2^{30} \approx 1$ billion bytes (1024 MB, a small library)
- A DVD is about 4.7 GB.
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Calculating with computer units

Let’s say you have a 16 GB USB stick.
  ▶ And a bunch of videos, 256 MB each.
  ▶ How many videos can it hold?

1024 = 256 \times 4, so you can fit four videos in one GB.

4 \times 16 = 64: 64 videos on the USB stick.

Beware!

Hard drive manufacturers use a different definition of kB, MB, etc!

They say that 1 kB is exactly 1000 bytes (not 1024).

⋆ And that 1 MB is exactly 1 million bytes, 1 GB exactly 1 billion.

⋆ When it gets to terabytes, that’s a difference of 10%!

⋆ Sometimes you will see “KiB”, “MiB”, “GiB”, “TiB”:

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Calculating with computer units

Let’s say you have a 16 GB USB stick.

- And a bunch of videos, 256 MB each.
- How many videos can it hold?
- $1024 = 256 \times 4$, so you can fit four videos in one GB.
- $4 \times 16 = 64$: 64 videos on the USB stick.

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- Hard drive manufacturers use a different definition of kB, MB, etc!
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- A **programming language** is a particular way of writing instructions to a computer.
- There are thousands of programming languages out there, dozens or hundreds of which are still in regular use.
  - A professional programmer usually knows several.
  - Then they can choose the right tool (language) for each job.
- In CS 115, we’ll learn to write programs in **Python**, a high-level, interpreted programming language.
In a given programming language:

- **Syntax** are the rules that say what programs look like
- **Semantics** are the rules that say what programs mean:
  - What does the computer do when it executes this statement?
  - When you combine these statements, what happens?
Syntax and semantics

In a given programming language:

- **Syntax** are the rules that say what programs look like:
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![Code examples]

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Neil Moore (UK CS)
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\[
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load r1, -2[sp]
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Interpreters and compilers

Underneath, the computer still understands only machine code. So if we write in a high-level language, we have to have a way to translate that language into machine code.

There are two general ways to do this: interpreters and compilers.

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Μπακλαβάς
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1. Have your friend stand with you in the kitchen, telling you each instruction in order—an interpreter.

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You can get started more quickly with the interpretation method, but you need your friend in the kitchen every single time.
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    - Jump from variable name to definition.
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- A **debugger** to help find and repair bugs.
  - Pause execution at a certain line.
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These are just some of the tools used by professional programmers.
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- Use a plain text editor, *not* a word processor.
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  - Notepad works.
  - Mac TextEdit: Format → Make Plain Text.

State the purpose of the program up top.
- Followed by your name, section, email, assignment number.

One step per line.
- Start the line with a `#` symbol (we'll see why next time).
- Indent and number substeps and repeated steps.
- Can number them 7.1, 7.2; or a, b, c: just make it clear.
- Hint: wait until the very end to number the steps.
- That way there is less to change if you have to rearrange your design.

Give your file a name ending in `.py` (Python code)
- Why? The design will be the basis for your implementation.
- You'll write code for each step of the design.

⋆ Before long, you'll have a working program.
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  - Followed by your name, section, email, assignment number.

- One step per line.
  - Start the line with a “#” symbol (we’ll see why next time).
  - Indent and number substeps and repeated steps.
  - Can number them 7.1, 7.2; or a, b, c: just make it clear.

- Hint: wait until the very end to number the steps.
  - That way there is less to change if you have to rearrange your design.

Give your file a name ending in `.py` (Python code)

- Why? The design will be the basis for your implementation.
  - You’ll write code for each step of the design.

⋆ Before long, you’ll have a working program.
How to do a design in CS 115

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  - Notepad works.
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Example program design

# Purpose: Ask for the user’s name and greet them.
# Author: J. Random Hacker, section 1,
# random.hacker@uky.edu
# Assignment: Lab 42
# Main program:
# 1. Input the user’s name from the keyboard
# 2. Output the word hello, followed by the user’s name.
Turned into code

We’ll see more about how this code works next time.

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# Assignment: Lab 42
# Main program:
def main():
    # 1. Input the user’s name from the keyboard
    name = input("What is your name? ")
    # 2. Output the word hello, followed by the user’s name.
    print("Hello ", name)
main()