Computer Basics and Algorithms
Learning Goals

• CT Building Block: Students will be able to define the difference between hardware, applications, and the operating system.

• CT Building Block: Students will be able to give examples of a problem for which there are different algorithms, give examples of cases where one algorithm works better than the other, and reason about which algorithm is likely to work better overall.

• CT Building Block: Students will be able to evaluate and compare algorithms in terms of its efficiency (time and space requirements).
Hardware vs. Software

- **Hardware** refers to the physical devices
- **Software** refers to programs that run on the hardware to implement applications
Computers have gotten much better at storing information in smaller spaces.

Today: 10nm

http://www.anandtech.com/show/2928

1 nm = 1 billionth of a meter!
How has this changed computing?

Eniac: ~18,000 pieces of data

My laptop: ~8,000,000,000,000 pieces of data

http://www.computerhistory.org
Computer memory vs. laundry: registers

• The CPU/“chip” actually does the work
• It includes registers, which hold the data that the computer is actively working with
• This is a bit like the clothes that you are actually wearing
• It’s very small, very fast to access
Computer memory vs. laundry: cache

• The CPU also has several layers of *caches* – fast memory that is actually on the chip
• This is a bit like keeping clean laundry in a small pile near where you put it on.
Computer memory vs. laundry: RAM

- The computer also has RAM. It’s not on the chip, but is on the motherboard.
- This is slower to access than the cache and a bit bigger, but fairly fast and fairly small
- This is a bit like keeping clothes in a small closet
The computer also has a hard drive/solid state drive (ssd)

This is not on the motherboard. It’s very slow to access, but generally much, much bigger

This is a bit like keeping clean laundry in a storage locker or at your parents’
Even though these distances seem small, they make a real difference.

Admiral Grace Hopper explains the nanosecond:
https://www.youtube.com/watch?v=9eyFDBPk4Yw
Making chips smaller also makes them faster, but that’s coming to an end: Moore’s Law no longer holds

“Intel cofounder Gordon Moore [...] observed in 1965 that every year twice as many [transistors] could fit onto a chip, and in 1975 adjusted the pace to a doubling every two years. [...] But Intel pushed back its next transistor technology, with features as small as 10 nanometers from 2016 to late 2017”

Making chips smaller also makes them faster, but that’s coming to an end: Moore’s Law no longer holds.

Computer speed and memory on a chip will double every 18 months to 2 years.

http://en.wikipedia.org/wiki/Moore's_law

Computational Thinking
http://www.ugrad.cs.ubc.ca/~cs100
Fortunately, not all computing speed up is due to hardware

White line is hardware speedup
Green line includes software speedup (note log plot)
Special note: Operating System

- An operating system is a special kind of software that allows the other software to run
- Most of you probably use Windows or Mac OS
So how does software work?

- Software works by programmers writing down algorithms in a special languages that the computer can understand.

- Reminder: an algorithm is a precise, systematic method for producing a specified result.

- Example: an algorithm for using the clicker
  1. Turn on the clicker by pressing the “On/Off” button.
  2. Select the clicker channel (AB)
  3. When I ask a question in class (and start the timer), select A, B, C, D, or E as your vote.
  4. If the Vote Status” Light is green, the vote was received.
    - Do nothing
    - Else
      - Vote again

http://www.ugrad.cs.ubc.ca/~cs100
That problem was human, but not very common. Let’s look at sorting again

Your “computer” sorts things for you every day

- E-mails
- Contacts
- Music

There’s so much sorting that a LOT of time has been devoted to coming up with ways to sort.
Before we can sort, we need to swap

An oven does not always heat evenly. So when making cookies to cook them evenly, you have to change positions of the cookies: the ones on the top go to the bottom, and the ones on the bottom go to the top.

In groups, create an algorithm to swap the location of the cookie sheets in the picture. Assume you only have one oven mitt… and don’t have burn-proof hands.
Let’s sort! Sorting algorithm #1: Simple sort

1. Place the unsorted cards in the top row
2. Repeat steps 3 through 6 until no unsorted card remains
   3. Initially mark the first (leftmost) card
   4. Working right from the second card, compare the marked card to the current card.
      If the current card is smaller than the marked card
      Move the marker to the current card
   5. Move the marked card to the sorted hand
   6. Put a “Max” (upside down) card in the empty unsorted slot
3. Stop
Computational Thinking

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Sorting algorithm #2: Selection Sort

1. Deal the unsorted cards
2. Put a divider at the left of the unsorted cards
3. Repeat steps 4 through 7 until one unsorted card remains
   4. Initially mark the first (leftmost) card
   5. Working right from the second card, compare the current card with the marked card.
      If the current card is smaller than the marked card, move the marker to the current card
   6. Swap the marked card with the first unsorted card (just to the right of the divider)
   7. Advance the divider to the right one card
8. Stop
Sorting algorithm #3: Insertion Sort

1. Deal the unsorted cards
2. Put a divider after the first card
3. Repeat steps 4 through 9 until no card is to the right of the divider
   4. Select the first card to the right of the divider. This is the “new” card.
   5. Select the rightmost of the cards before the divider. This is the “old” card
   6. Repeat steps 8 and 9 until there is no “old” card, or the value of the “new” card is less than the value of the “old card”
      7. If the “new” card is less than the “old” card, swap the two
      8. Let the “old” card be the card to the left of the cards just compared
   9. Advance the divider to the right one card
10. Stop
There are many ways to define “best”

Common ones are time and space

We’ll start with space

Things that take space include:
• memory slots for cards
• markers, dividers
We’ll concentrate on memory slots
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