What's in a computer?

• **logical or functional organization:** "architecture"
  - what the pieces are, what they do, how they work
  - how they are connected, how they work together
  - what their properties are

• **physical structure**
  - what they look like, how they are made

• **major pieces**
  - processor ("central processing unit" or CPU)
    does the work, controls the rest
  - memory (RAM = random access memory)
    stores instructions and data while computer is running
  - disks ("secondary storage")
    stores everything even when computer is turned off
  - other devices ("peripherals")
2018 freshman SCI computers

Apple Macbook Pro 13" Retina
- 2.6 GHz Intel Dual Core i5 processor
- 13.3" retina display
- Intel Iris Graphics
- 8 GB memory
- 128 GB PCI-e Flash Storage
- Ethernet and VGA Adapters included
- Mac OS X 10.9 Mavericks

Dell XPS 12
- 4th Generation Intel Core i7 1.8 GHz processor (4M Cache, up to 3.0 GHz)
- 12.5 inch LED Backlit Touch Display FHD resolution (1920 x 1080)
- Intel HD 4400 Graphics
- 8 GB memory
- 256GB Solid State Drive
- Convertible Laptop to Tablet
- Ethernet and VGA adapters incl., 3.35 lbs.
- Windows 8.1 Pro
Block diagram of typical laptop/desktop

- **CPU** (processor)
- **Memory** (RAM)
- **Hard disk**
- **CD/DVD**
- **Network/wireless** (and many others)
- **Display**
- **Mouse**
- **Keyboard**
- **Bus**
CPU

- can perform a small set of basic operations ("instructions")
  - arithmetic: add, subtract, multiply, divide, ...
  - memory access:
    fetch information from memory, store results back into memory
  - decision making: compare numbers, letters, ...
    decide what to do next depending on result of previous computations
  - control the rest of the machine
    tell memory to send data to display; tell disk to read data from network; ...

- operates by performing sequences of simple operations very fast

- instructions to be performed are stored in the same memory as the data is
  - instructions are encoded as numbers: e.g., Add = 1, Subtract = 2, ...

- CPU is a general-purpose device: putting different instructions into the memory makes it do a different task
  - this is what happens when you run different programs
How fast is fast?

- **CPU** uses an internal "clock" (like a heartbeat) to step through instructions

- **900 MHz, 2.5 GHz, etc.,** is the number of clock ticks per second
  - 1 Hertz = 1 tick per second; abbreviated 1 Hz
  - mega = million
  - giga = billion
  - 1 MHz = 1 megaHertz = 1 million ticks per second
  - 1 GHz = 1 gigaHertz = 1 billion ticks per second = 1000 MHz

- one instruction (like adding two numbers) might take one, two or several ticks, depending on design of the CPU
  - might even complete more than one instruction in one tick

- **very rough approximations:**
  - PC/Mac processors execute about 2-3 billion instructions/sec
  - cellphone processors execute about 1-2 billion instructions/sec
Memory (Random Access Memory = "RAM")

- a place to store information while the computer is running
  - the programs that are running
  - their data
  - the operating system (Windows, Mac OS X, Unix/Linux, ...)
- volatile: forgets everything when power is turned off
- limited (though large) capacity
- logically, a set of numbered boxes ("pigeonholes"? mailboxes?)
  - each capable of storing one byte = 8 bits of information
    - a small number or a single character like A or part of a larger value
  - random access
    - CPU can access any location as quickly as any other location

```
0  1  2  ......  4G
```
What's a bit? What's a byte?

- **a bit is the smallest unit of information**
- represents one 2-way decision or a choice out of two possibilities
  - yes / no, true / false, on / off, M / F, ...
- abstraction of all of these is represented as 0 or 1
  - enough to tell which of TWO possibilities has been chosen
  - a single digit with one of two values
  - hence "binary digit"
  - hence bit
- **binary is used in computers because it's easy to make fast, reliable, small devices that have only two states**
  - high voltage/low voltage, current flowing/not flowing (chips)
  - electrical charge present/not present (Flash)
  - magnetized this way or that (disks)
  - light bounces off/doesn't bounce off (cd-rom, dvd)
- all information in a computer is stored and processed as bits
- a byte is 8 bits that are treated as a unit
Disks

- a place to store information when the power is turned off
- often based on magnetic surfaces, rotating machinery
  - increasingly solid-state Flash memory
- logical / functional structure: folders (directories) and files
  - your information: papers, mail, music, web page, ...
  - programs and their data: Firefox, Word, iTunes, ...
  - operating system(s): Windows, MacOS, Unix, Linux, ...
  - bookkeeping info: where things are physically located
Other views of a disk: Window, Unix/Linux
Other things

- **CD-ROM, CD-R, CD-RW; DVD**
  - read-only, recordable, rewritable, ~ 650 MB capacity
  - same format as audio CD but spins much faster
  - DVD: typically 4.7 or 8.4 GB

- **modem**
  - converts info to/from sound for sending by telephone
  - slow! 56 kilo\textbf{bits} per second (56 Kbps): ~ 5000 characters/second

- **network interface**
  - connects computer to network, usually Ethernet
  - Ethernet transfers data at 10-1000 mega\textbf{bits} per second
    (10 Mbps ~ 1 MB/sec)
  - wireless is compatible with Ethernet ("wireless Ethernet")
    802.11b (11 Mbps), 802.11g (55 Mbps), 802.11n (600 Mbps) [max]
  - DSL and cable modems are Ethernet-compatible
    slower than Ethernet (typically 0.5 - 4 Mbps); usually at home
  - fiber (e.g., Verizon FiOS) at least 15 Mbps down, 5 Mbps up (higher==$$$$)

- **gadgets ("peripherals") on the bus, especially USB**
  - USB 2.0 is 480 Mbps (max)
Wrapup on components

- the logical or functional components of computer hardware
- how they fit together, what the numbers measure
- some neat Greek/Latin/... prefixes:
  - (femto, pico,) nano, micro, milli, kilo, mega, giga, (tera, peta, exa)
- what the basic physical pieces look like
- one logical organization can have different physical forms
- logical organization hasn't changed much in 60+ years
- physical form has changed rapidly for the entire time
  - many tradeoffs among physical forms (size, weight, power, ...)