Welcome to AP Computer Science Principles (AP CSP)

Hello! I am happy to have you in my AP Computer Science Principles class for the 2023-2024 school year!

This class is about the principles that underlie much of the technology around us. Your job as a student in the class is to be on the lookout, to be alert, for where and how computer science affects or impacts the things you care about, the things you know about. Whatever it is you want to do in your life, it is likely that technology affects it in some way, or that some technological innovation is needed.

This course is about creativity, technology, and innovation. In this class, you will often be asked to invent your own solution to problems. Even if it is a problem that has been solved before, thinking like a computer scientist requires a different mindset. We study a lot of things in this class not only because it's foundational knowledge, but because of the way it makes you think, the way it asks you solve problems.

Inventing things, and having insights about how things work, and how they might work better is what this class is about. The goal of the summer assignment is to get you started on this way of thinking as well as get you familiar with what a computer actually is.

I look forward to having you all in the fall. Have a great rest of your summer break! If you ever need me, email me at harristm@scsk12.org.

~Mr. Harris

Summer Assignment 2023

- The assignment below is due the first day we all meet and will count as **2** quiz grades.
- **There will be a test on Friday, August 25, 2023** on material covered in the assignment; however, we will review before.

Part 0

Download the Guided Notes and use them to complete Parts 1 & 2

Part 1

- Read Chapters 1 & 2 of *Blown to Bits* - free pdf here
  - If you search for, or purchase, this book, make sure it is the second edition (linked for you). There is a version about 10 years older than the one linked here with an orange-ish cover - DON'T READ THIS ONE!
- The first 2 pages of the handout are in the book.

Part 2

- Complete the Hardware section and answer the rest of the guided notes based on the **Notes**, **Reference Sheets**, **Video**, and **Slides**; make sure to utilize all the materials to answer the questions
- I promise you won't have to watch hour long videos every night. If I assign videos to watch, they will be broken up from here on out.

- **DO NOT** do any of the Problems for the Hardware section, but do look over them as you may see something similar on the test

Hardware

Binary

- We use computers everyday.
- Inside a computer are “0s and 1s”
    - Computers use the binary number system to represent info
        - How do computers represent info with just binary?
- Consider the decimal number (what we human typically use) 123
    - The rightmost column is the 1s column
    - The middle, the 10s
    - The leftmost, the 100s

100	10	1
1	2	3

    - Thus we have 100 x 1 + 10 x 2 + 1 x 3 = 100 + 20 + 3 = 123
- Inside a computer, the binary 000 would represent 0, just like in our human world!

- However, in this case we are dealing with binary so:
    - The right most column is the 1s place
    - The middle, the 2s
    - The leftmost, the 4s

4	**2**	**1**
0	0	0

- In the human world (decimal) we use powers of 10 for place values
    - $10^0 = 1$, $10^1 = 10$, $10^2 = 100$, $10^3 = 1000$, etc.
- In the computer world (binary) we use powers of 2 for place values
    - $2^0 = 1$, $2^1 = 2$, $2^2 = 4$, $2^3 = 8$, etc.
- The difference between decimal numbers and binary numbers is changing the base
- For the binary number 000, we have 4 x 0 + 2 x 0 + 1 x 0 = 0 + 0 + 0 = 0!

- Consider the binary number 001:

4	**2**	**1**
0	0	0

  - We have 4 x 0 + 2 x 0 + 1 x 1 = 0 + 0 + 1 = 1
- How do we represent the decimal number 2 in binary?
  - We don’t need a 4, be we need a 2, and also no 1

4	**2**	**1**
0	1	0

  - This gives us 4 x 0 + 2 x 1 + 1 x 0 = 0 + 2 + 0 = 2

- Likewise, the number 3 would be:

4	**2**	**1**
0	1	1

  - As we need a 2 and a 1
  - Thus, 4 x 0 + 2 x 1 + 1 x 1 = 0 + 2 + 1 = 3

- Similarly, 4 would be:

4	**2**	**1**
1	0	0

- What about 7?

4	2	1
1	1	1

    - Which yields 4 x 1 + 2 x 1 + 1 x 1 = 4 + 2 + 1 = 7
- What about 8?
    - We can't count to 8 without another bit (binary digit)
        - We run into this in the real world too if we need a four-digit number vs a 3-digit number
            - Start with the 1s, 10s, 100s place and add the 1000s
        - Here we'll add the next power of 2, 8

8	4	2	1
1	0	0	0

        - 8 x 1 + 4 x 0 + 2 x 0 + 1 x 0 = 8
- Just like decimal numbers (base 10), numbers represent larger values on the left side and decrease as we move right.
- So if we wanted to compare the binary numbers 1001 and 1010 we could start on the far left side of the number and look for where the numbers differ. The one with a 1 will be larger than the one with a 0.

8	**4**	**2**	**1**
1	0	***0***	1
1	0	***1***	0

- Even though computers only use binary, they can count as high as humans can!
    - They do it with a smaller vocabulary, just 1 and 0.
        - This is because it's easier to represent two states in the physical world
            - If you think of one of these bits as being a light bulb:
                - 0 is off
                - 1 is on
            - Light bulbs just need electricity to turn on or off
            - Electricity is sufficient to turn a switch on or off
                - Inside a computer exists these switches called transistors
                    - Modern computers have billions!
                    - Turned off represents 0
                    - Turned on represents 1
- Using these transistors we can store values, store data, compute, and do everything we can with computers
- David demonstrates how transistors work using light bulbs
- So far all that we can represent is numbers

- A decision needs to be made on what pattern of 1s and 0s to represent letters, words, and paragraphs
- All computers can store is 0s and 1s
- To represent letters, we need a mapping of 0s and 1s to characters
    - ASCII (American Standard Code for Information Interchange) does this

0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

    - 65 -> A, 66 -> B, 67 -> C, etc.
    - 97 -> a, 98 -> b, 99 -> c, etc.
    - ASCII also has mapping for punctuation symbols
- Programs like notepad, textedit, and Microsoft Word decide weather to display patterns of bits as letters or words
    - Computers only store 0s and 1s, but the programs interpret those bits in a certain way

      - For example, if Microsoft Word sees a pattern of buts representing the number 65, it will interpret that as “A”
  - ASCII is limited
    - Original ASCII is 7 bits, thus giving 128 characters
      - Extended ASCII is 8 bits, yielding 256 characters
    - Many symbols are not represented
  - UNICODE is a bigger set of characters that includes written languages other than English and even emoji! 😲
    - All are still represented by a pattern of bits
- Consider this pattern of bits: 01001000 01001001
  - 16 bits or 2 bytes (1 byte = 8 bits)

<table>
<tr><th>128</th><th>64</th><th>32</th><th>16</th><th>8</th><th>4</th><th>2</th><th>1</th><th></th><th>128</th><th>64</th><th>32</th><th>16</th><th>8</th><th>4</th><th>2</th><th>1</th></tr>
<tr><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td></td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
<tr><th colspan="8">1 x 64 + 1 x 8</th><th colspan="9">1 x 64 + 1 x 8 + 1 x 1</th></tr>
<tr><td colspan="8">72</td><td colspan="9">73</td></tr>
<tr><td colspan="8">H</td><td colspan="9">I</td></tr>
</table>

  - Using ASCII we get the word “HI”

- If you have heard that your computer has “Intel Inside,” it has an Intel processor in it

CPU

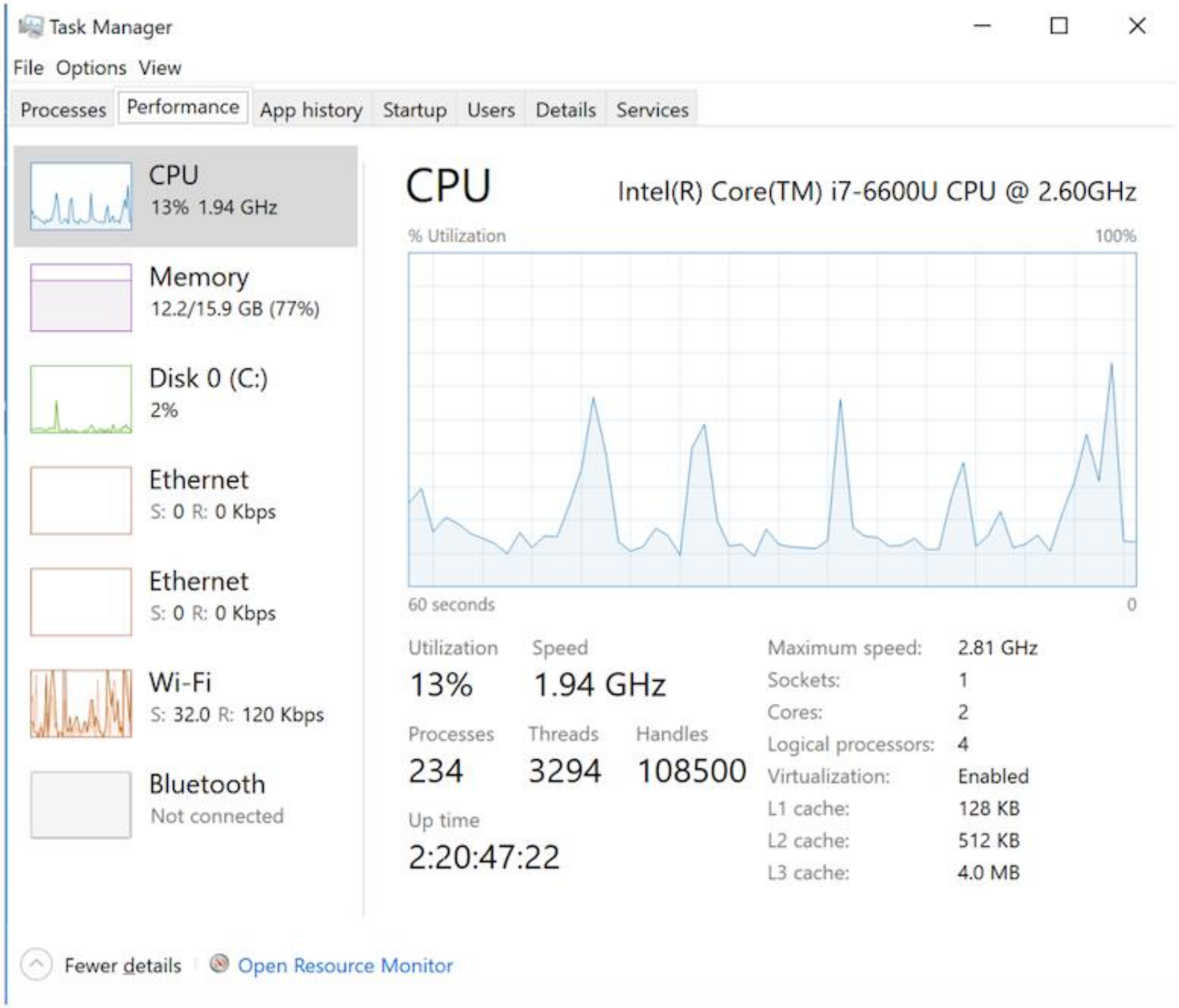
- The backside of the processor has pins that connect into the motherboard
- The motherboard is a circuit board made of silicon
- The CPU is the brain of the computer
    - Does all the thinking
    - Performs math in numbers fed to it
    - Helps display numbers on a screen
    - Adds or deletes numbers
- CPUs now can have multiple cores
    - Cores are the devices inside the CPU that can preform mathematical operations, load info from memory, save info to memory, etc.
    - The more cores, the more tasks a CPU can do at once
- CPUs now also support hyper-threading
    - Where a single core will present itself as multiple cores to a computer's operating system

- Systems on a Chip (SoaC) are when a CPU and more are all interconnected at once rather than attached to a motherboard
    - Popular in phones, tables, and game consoles
    - Raspberry Pi

RAM (Random Access Memory)

- Circuit board with chips that slides into a slot on the motherboard

    - The chips store data
        - Only stores data when the power is on
    - Files and programs are loaded onto these chips when ran
    - Fast memory
- You can check your RAM and other specs:
    - Windows Task Manager



- CPU chart shows when peak usage occurs
- GHz is the number of operations a CPU can perform per second (in billions)

        - 1.94 GHz = 1.94 billion operations per second
    - Logical processors in this case is 4, which means both cores support hyper-threading
        - Each core will do two things at once as if 4 cores exist
- Mac System Profiler

Hardware Overview:

Model Name:	MacBook Pro
Model Identifier:	MacBookPro12,1
Processor Name:	Intel Core i7
Processor Speed:	3.1 GHz
Number of Processors:	1
Total Number of Cores:	2
L2 Cache (per Core):	256 KB
L3 Cache:	4 MB
Memory:	16 GB

Hard Drives

- When you turn a computer off, you need a place to store data
    - A hard disk drive (HDD) stores this information

    - RAM may store 1 GB, 2 GB, 4 GB, through 16 GB or so
    - HDD stores 256 GB, 1024 GB (AKA terabyte or TB), 2 TB
    - Inside a HDD, metal platters physically spin around

- Data is stored on these disks
- The reading heads move back and forth reading data from the device
- Uses tiny magnetic particles where north pole orientation represents 1 and south pole orientation represents 0
    - Power is only needed to read or change the data
        - Data is preserved when power is off

        - David shows a video of a HDD running in slowmo
- To store data in a hard drive, RAM sends data and instructions to the HDD
    - The hard drive translates that data into voltage fluctuations
        - Some signals spin the platters, others move the read/write heads
        - Pulses sent to the read/write head turn on a magnet which creates a field that changes the polarity of a tiny portion of the metal platter's surface
        - Power is sent in different directions as to change polarity
    - To read, the particles on the disk use their charge to move the read/write head.
    - Pieces of a file can be spread out around the platters
        - A special file keeps track of data's location
    - Anytime you have a physical device that moves over a period of time, things go wrong
        - Dropping a HDD can corrupt files
    - Platters spin slower than how fast electrons move

Flash Memory

- Solid state disk (SSD)

  - Smaller (3.5 inch width for HDD vs 2.5 inch width for SSD)
    - Still fits where old HDDs are
  - No moving particles
  - Inside, it looks a lot like RAM

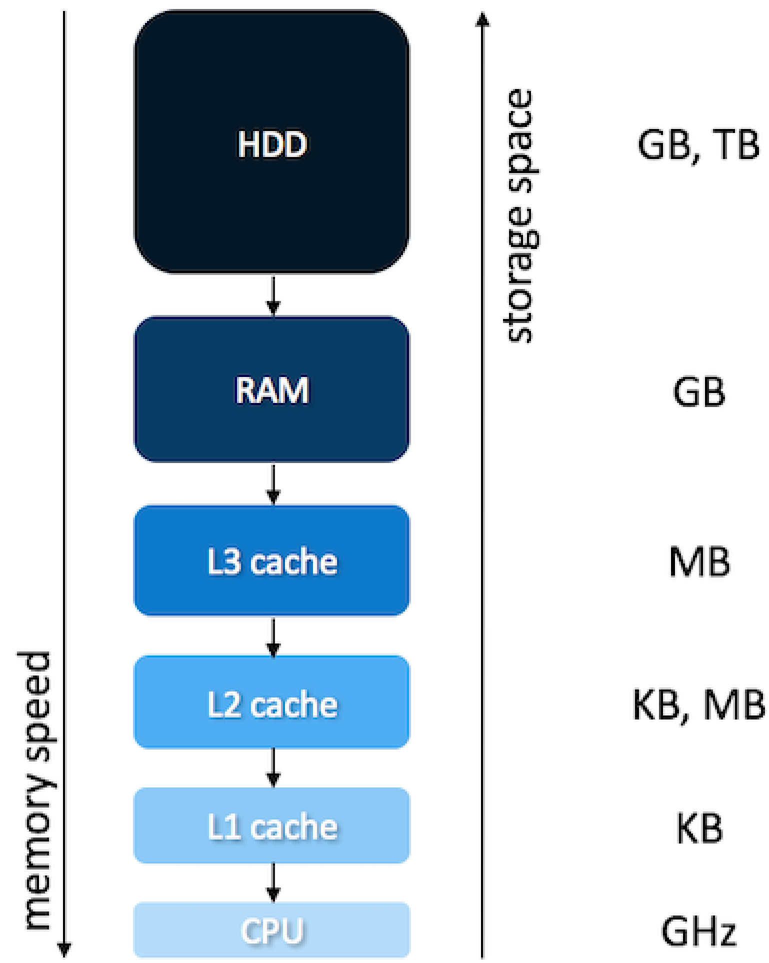
    - Much faster than HDD
        - Programs/files load and save more quickly
    - SSD theoretically don’t last as long as HDD
        - Finite number of writes
- Hybrid Drives
    - Some GB of solid state memory and more GB or TB of HDD space
    - Stores as much of frequently-needed data on the SSD
    - Stores less frequently-needed data on HDD
- Flash memory also exists in the form of USB sticks
    - Might store 1 GB, 16 GB, or more
    - Portable

- External SSDs exist for more storage
    - Might store 256 GB or more
    - Can be used to share data with others without network usage
- Can also have external HDD

Types of Memory and Funneling

- There is a tradeoff between space, money, and speed of data transfer

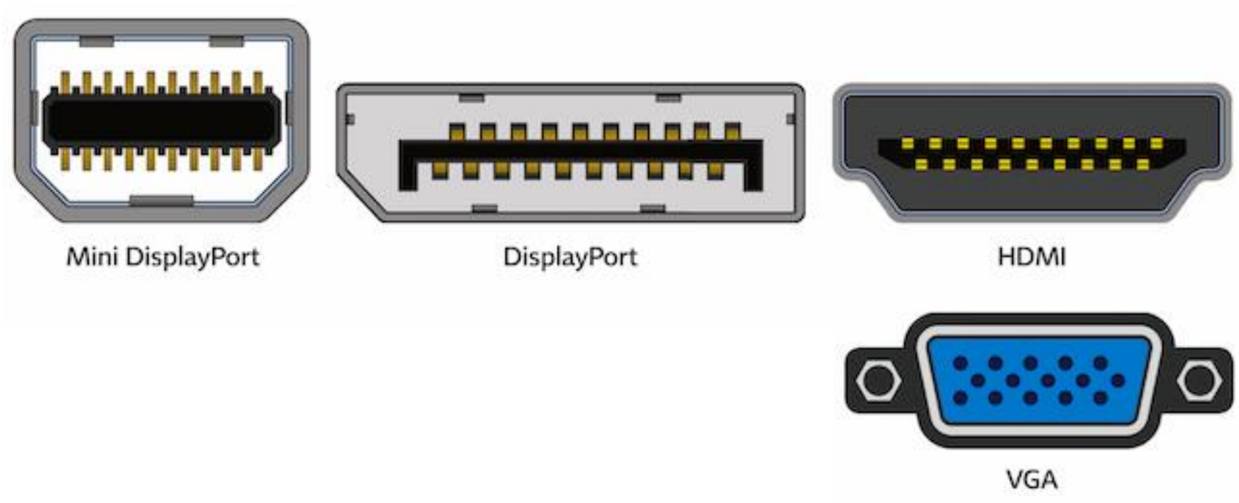
    - Data is pushed “down the funnel” to your CPU
        - From the hard drive, data first goes to the RAM



- Theoretically, the CPU never has to wait for data to crunch
- There is a tiny amount of memory (bytes) called registers where numbers are stored for operations.

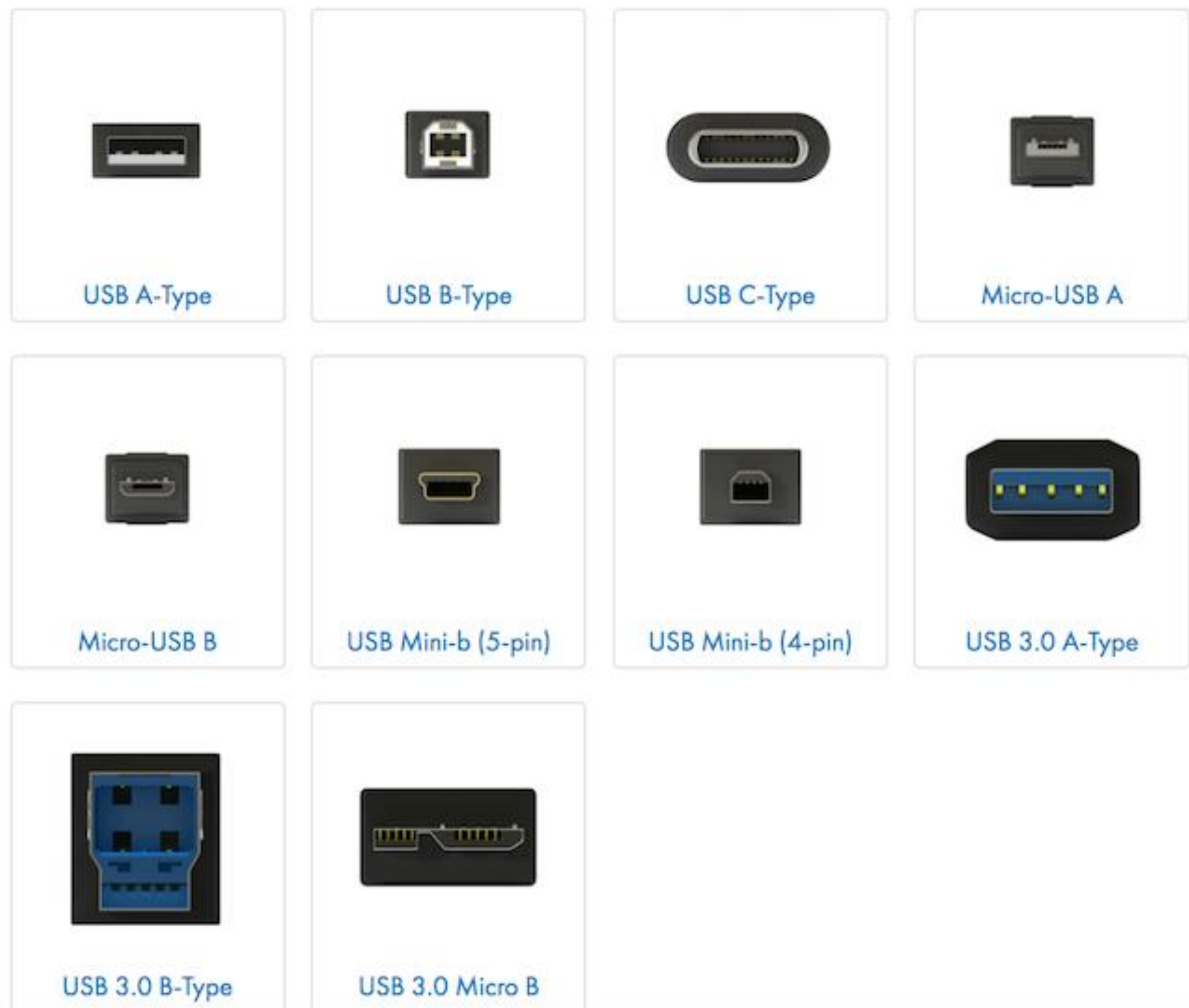
        - Memory at the bottom is more expensive
        - Disk is important for the long-term storage
        - RAM is important as it stores programs you use simultaneously
        - L3, L2, L1 cache are on the motherboard
- As an analogy for memory, picture a candy store
    - A customer approaches the counter and requests candy
    - The shop owner then leaves the counter to grab the candy before returning moments later
        - Not super efficient to walk all the way to the store room to grab candy
            - Better to have a cache of memory
    - Instead, the shop owner leaves the counter to ready a cache of candy before the customers arrive
    - When a customer comes, the candy can be distributed quickly
        - Cache memory similarly helps the CPU in this manner
- We can see sizes of cache looking at computer specs like before

Display Connectors



- These sockets all connect to monitors or displays
- Mini DisplayPort are used form monitors
- HDMI is not only on laptops and computers but also TVs
- VGA is older, but still commonly uses on projectors

Universal Serial Bus (USB)



- Can plug in a whole range of peripheral devices including printers, keyboards, mice, scanners, etc.
- USB-A most common
- USB-B is often used for printers and scanners
- USB-C is newer and can be plugged in coming from different directions
- Other variants often exist for phones
- Older USB connections are slower when transferring data
    - Hard drives can connect via USB
        - Even if a hard drive is fast, if the USB is slow, the transfer of data will be slow

Wireless

- Wifi is wireless internet
- Bluetooth allows devices such as wireless keyboards and headphones to connect to your computer
    - Limited range
        - This is ok as it is used for you to connect to your own device

Operating System

- Software that ensures all devices work and can intercommunicate
- MacOS and Windows are popular OS
- Can be installed by the user, but is typically done so by a manufacturer
    - Installed on HDD or SDD so that it exists persistently without power
- When you hit power on your computer, the OS is loaded into RAM
- Gives you the graphical interface that you see

- Knows how to:
  - Talk to your keyboard and mouse
  - Display info on the screen
  - Move things around in memory
- This is all thanks to device drivers installed with the OS
  - Special software designed to talk to certain model of printer, camera, scanner, etc.
- When an OS doesn't recognize a device, perhaps because it's too new, you can download new device drives from the device manufacturer
  - Teaches Window, MacOS, or Linux about that new hardware
  - Future-proofing structure
- It's this intersection of hardware and software that makes computers powerful!

Looking Underneath the Hood

- David and Colton Ogden look at the exterior of an old ThinkPad computer, examining ports
  - Power bricks convert power from the wall into safe amounts for the computer
- David and Colton examine the inside of an old window desktop, highlighting the motherboard, heatsink, RAM, Hard Drive, etc.
- David and Colton then look inside a HDD
  - Once exposed to air and dust, it's no longer reliable enough to use
- David and Colton then look at a motherboard examining all the ports on it

- Reference Sheets
  - Computers and Computing
  - How Computers Work
  - Memory
  - CPU and SoC
  - Transistors and Logic
- Video
- Slides
- Problems
  - Around the House
  - Tech Spot
  - Everyday Algorithms
  - Me, myself and UI