

# Week 2

## Computer Hardware

Week2  
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**This item** 2020 Newest ASUS VivoBook 15.6" FHD Thin Light Business Student Laptop, AMD Ryzen 5 3500U(Best 17-7500U) 8GB RAM 128GB SSD+ 500GB HDD, Radeon Vega 8, Fingerprint, HDMI, USB-C, Win10, w/GM Accessories

Add to Cart

2020 Newest ASUS VivoBook 15.6" Full HD Laptop AMD Ryzen 7 3700U 12GB RAM 512GB SSD Radeon RX Vega HDMI WiFi Bluetooth 10 Windows 10 Home Silver

Add to Cart

**15.6" BACKLIT KEYBOARD**  
**8GB DDR4 RAM**  
**256GB SSD**




2020 ASUS VivoBook 15 15.6 Inch FHD 1080P Laptop (AMD Ryzen 3 3200U up to 3.5GHz, 8GB DDR4 RAM, 256GB SSD, AMD Radeon Vega 3, Backlit Keyboard, FP Reader, WiFi, Bluetooth, HDMI, Windows 10) (Grey)

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2020 Newest Acer Aspire 5 Slim Laptop 15.6 FHD IPS Display, AMD Ryzen 3 3200u-Dual Core (up to 3.5GHz), Vega 3 Graphics, 8GB RAM, 128GB PCIe SSD + 500GB HDD, Windows 10 w/Ghost Manta Accessories

Add to Cart

Customer Rating	★★★★☆ (32)	★★★★☆ (55)	★★★★☆ (111)	★★★★☆ (122)
Price	\$599 <sup>00</sup>	\$729 <sup>00</sup>	\$505 <sup>00</sup>	\$539 <sup>00</sup>
Sold By	AMAZING WAREHOUSE DEAL(Record SN)	UltraGeek	Trusted eStore	AMAZING WAREHOUSE DEAL(Record SN)
Computer Memory Size	8 GB	12 GB	8 GB	8 GB
CPU Model Manufacturer	AMD	AMD	AMD	AMD
CPU Speed	2.10 GHz	2.3 GHz	2.6 GHz	2.60 GHz
Display Resolution Maximum	1920 x 1080 pixels	1920 x 1080 pixels	1920 x 1080	1920x1080 pixels
Screen Size	15.6 inches	15.6 inches	15.6 inches	15.6 inches
Display Technology	LED	LED	—	LED
Hard Disk Size	128 GB	512 GB	256 GB	128 GB
Item Dimensions	14.10 x 9.10 x 0.80 inches	14.10 x 9.10 x 0.80 inches	14.40 x 9.10 x 0.80 inches	14.31 x 9.74 x 0.71 inches
Item Weight	3.51 lbs	3.80 lbs	3.80 lbs	3.97 lbs
Operating System	Windows 10	Windows 10	Windows 10 Home	Windows 10
Processor Count	4	4	2	2
RAM Type	DDR4 SDRAM	DDR4 SDRAM	DDR4 SDRAM	DDR4 SDRAM
Wireless Communication Standard	Bluetooth	Bluetooth	802.11ac	802.11ac, Bluetooth

		
<b>MacBook Air</b> From \$999 or \$83.25/mo. for 12 mo.**	<b>MacBook Pro 13"</b> From \$1299 or \$108.25/mo. for 12 mo.**	<b>MacBook Pro 16"</b> From \$2399 or \$199.91/mo. for 12 mo.**
13.3-inch Retina display <sup>1</sup>	13.3-inch Retina display <sup>1</sup>	16-inch Retina display <sup>1</sup>
Up to 4-core Intel Core i7 processor	Up to 4-core Intel Core i7 processor	Up to 8-core Intel Core i9 processor
Up to 16GB memory	Up to 32GB memory	Up to 64GB memory
Up to 2TB storage <sup>2</sup>	Up to 4TB storage <sup>2</sup>	Up to 8TB storage <sup>2</sup>
Up to 11 hours battery life <sup>3</sup>	Up to 10 hours battery life <sup>3</sup>	Up to 11 hours battery life <sup>3</sup>
Touch ID	Touch Bar and Touch ID	Touch Bar and Touch ID
Backlit Magic Keyboard	Backlit Magic Keyboard	Backlit Magic Keyboard

## Factors to consider in buying a computer

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Computer component	Consideration
Platform	Does the software I need requires specific platform?
Hardware	Do I require specific hardware for my tasks? How much data di I plan to store?
Hardware specifications	Does the software I want to run require certain hardware specification?
Form factor	Where will I use the computer? Mobile or in one location?
Add-on devices	What additional devices will I need?

## Storage Capacity

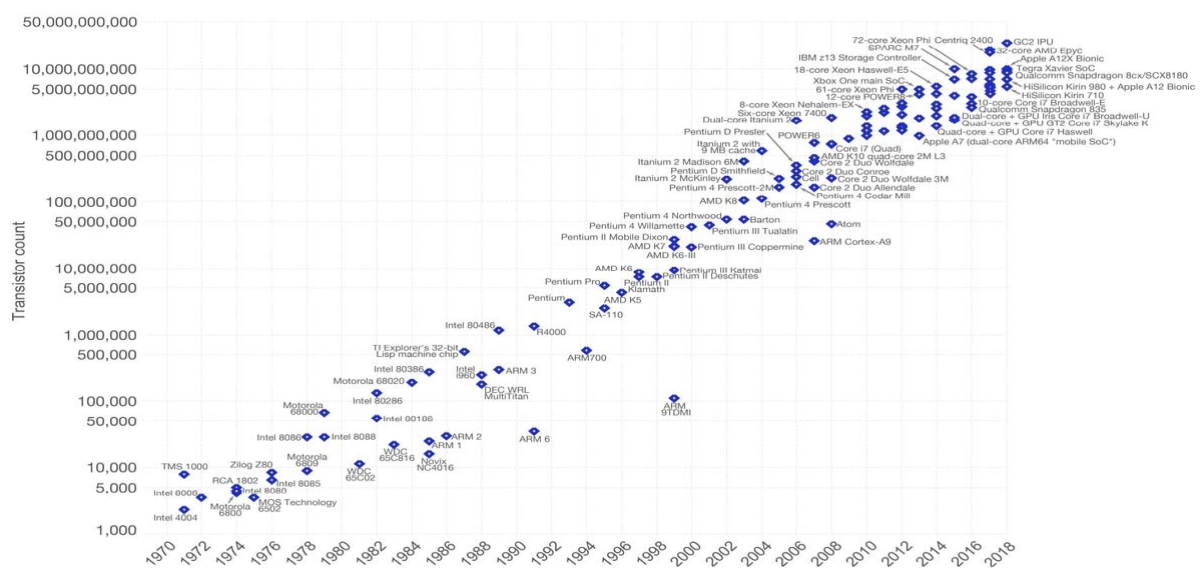
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Capacity is the number of bytes that a storage medium can hold

Storage Term	Approximate Number of Bytes	Exact Number of Bytes
Kilobyte (KB)	1 thousand	$2^{10}$ or 1,024
Megabyte (MB)	1 million	$2^{20}$ or 1,048,576
Gigabyte (GB)	1 billion <b>1GB=1000MB</b>	$2^{30}$ or 1,073,741,824
Terabyte (TB)	1 trillion <b>1TB=1000GB</b>	$2^{40}$ or 1,099,511,627,776
Petabyte (PB)	1 quadrillion	$2^{50}$ or 1,125,899,906,842,624
Exabyte (EB)	1 quintillion	$2^{60}$ or 1,152,921,504,606,846,976
Zettabyte (ZB)	1 sextillion	$2^{70}$ or 1,180,591,620,717,411,303,424
Yottabyte (YB)	1 septillion	$2^{80}$ or 1,208,925,819,614,629,174,706,176

## Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.

Our World  
in Data

Data source: Wikipedia ([https://en.wikipedia.org/wiki/Transistor\\_count](https://en.wikipedia.org/wiki/Transistor_count))  
This data visualization is available at [OurWorldinData.org](https://ourworldindata.org). There you find more visualizations and research on this topic.

Licensed under CC-BY-SA by the author Max Roser.

## Transistor and Integrated Circuit

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### Transistor

A semiconductor device used to amplify or switch electronic signals and power



Image credit: <https://en.wikipedia.org/wiki/Transistor>

### Integrated circuit (IC or chip)

A set of electronic circuits on one small flat piece (or chip) of semiconductor material

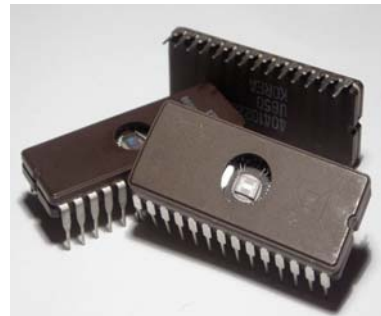


Image credit: [https://en.wikipedia.org/wiki/Integrated\\_circuit](https://en.wikipedia.org/wiki/Integrated_circuit)

## What is CPU

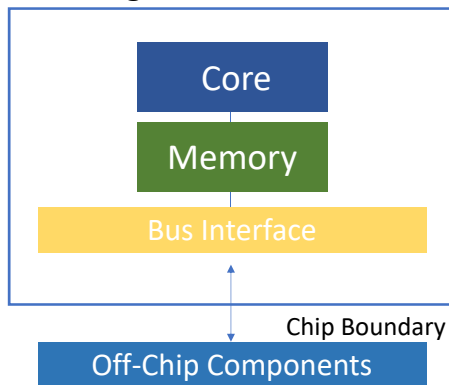
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- **CPU:** central processing unit, also called central processor
  - Interpret and carry out the basic instructions
  - Converting input into meaningful output
- **Bus:** what data travels in and out of the CPU
- **Single vs. multi-core processors**
  - A multi-core processor is a single chip with two or more separate processor cores
  - Multi-core processor can do parallel computing
    - Single:  $5 \times 4 \times 3 \times 2$  (one by one)
    - Multi:  $5 \times 4 = 20$ ,  $3 \times 2 = 6$ , then  $20 \times 6 = 120$

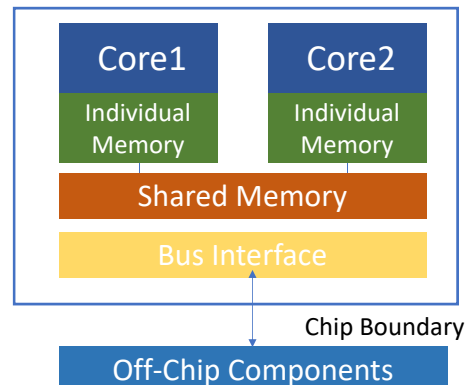
## Multi-core processor

1

### Single Core Processor



### Multi Core Processor



Source: <https://www.curtiswrightds.com/news/blog/certification-in-multi-core-cots-modules-when-sharing-is-a-challenge.html>

## Control Unit and ALU

When running an application:

Instructions are transferred from storage device to memory

**Control unit** directs and coordinates the instruction flow in the computer

- Control unit interprets and executes the instructions in the memory

ALU performs arithmetic and comparison operations

- ALU performs calculations on data in memory

The results (info) are stored in memory

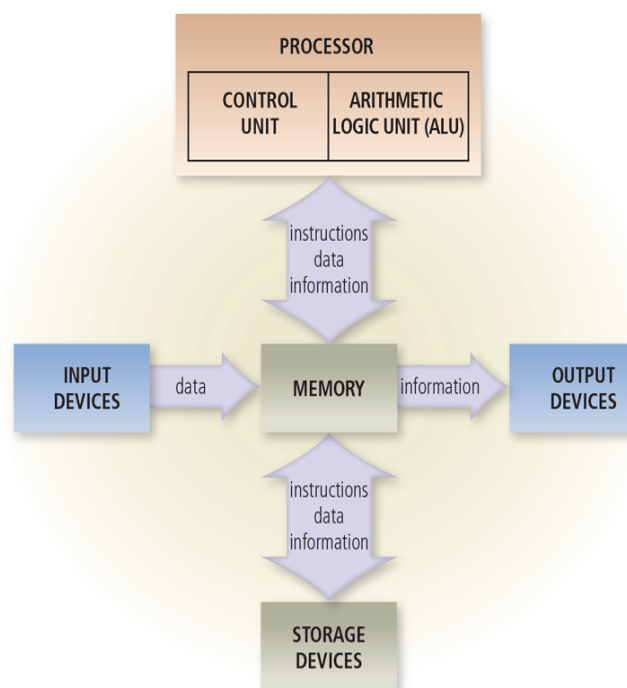


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

## Machine Cycle

For each instruction, the processor repeats a set of four basic operations

- **Fetch:** Control unit **fetches** instructions or data from memory
- **Decoding:** Control unit **decodes** instructions and send data and instructions to ALU
- **Execute:** ALU **executes** command (perform calculation)
- **Storage:** The results are stored in memory
- Execute and store instructions

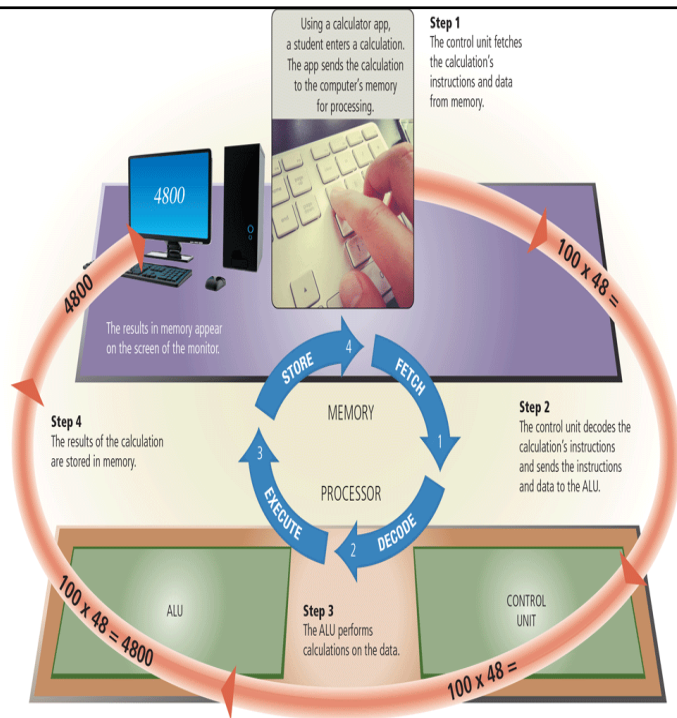


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

## Measure CPU Performance

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**Clock speed:** measures the num of cycles your CPU can execute per second

- Higher clock speed → faster CPU
- Cycle: the smallest unit of time that a process can measure
  - Megahertz (MHz): millions of cycles per second
  - Gigahertz (GHz): billions of cycles per second

**Bus:** an electronic channel that allows the CPU and various devices to communicate with each other

- **Bus speed:** num of times a group of bits can be sent each second
- **Bus width (word size):** num of bits that can be sent to the CPU simultaneously
  - Wider bus → more data can be transferred
  - 32-bit vs. 64-bit system

**Benchmark test:** test run by a laboratory to determine processor speed

### 裝置規格

裝置名稱	DESKTOP-6PKHJCB
處理器	AMD Ryzen 7 2700X Eight-Core Processor 3.70 GHz
已安裝記憶體(RAM)	32.0 GB
系統類型	64 位元作業系統, x64 型處理器

Processor	Score
Intel Core i9-10900K 3.7 GHz (10 cores)	1416
Intel Core i9-9900KS 4.0 GHz (8 cores)	1407
Intel Core i7-10700K 3.0 GHz (8 cores)	1356

Image credit: <https://browser.geekbench.com/processor-benchmarks>

## CPU vs. GPU (Graphics Processing Unit)

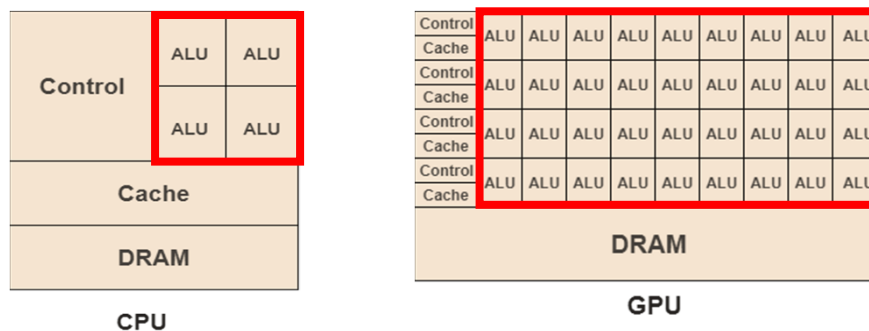
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CPU can act alone to process complex logical operations and different data types

- Good at handling a wide-range of tasks quickly
- Limited in the concurrency of running tasks

GPU cannot work alone and must be called by the CPU to work

- Good at repetitive and highly-parallel computing tasks
- Parallel computing: deal with a large amount of data with similar processing type



## Reading and Writing Processes

1

A **storage device** is the hardware that used to record and/or retrieve items to and from storage media



**Reading** is the process that transferring items from a storage medium into memory



**Writing** is the process of transferring items from memory to a storage medium



## Storage

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- A storage medium is the **physical** material on which a **computer stores data**, information, programs, and applications
- **Cloud** storage keeps information on **servers** on the Internet, and the actual media on which the files are kept are transparent to the user

Internal hard drive for a laptop



Photo by [Vincent Botta](#) on [Unsplash](#)

USB flash drive



Image by [FlitsArt](#) from [Pixabay](#)

Memory cards



Image by Photo Mix from Pixabay

External hard drive



Photo by : [Jessica Lewis](#) · from : [Pexels](#)

## Access Time

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### Access time measures:

- The amount of time that a storage device takes to locate an item on a storage medium
- The time required to deliver an item from memory to the processor
- Memory is faster but more expensive
- Storage is cheaper but slower

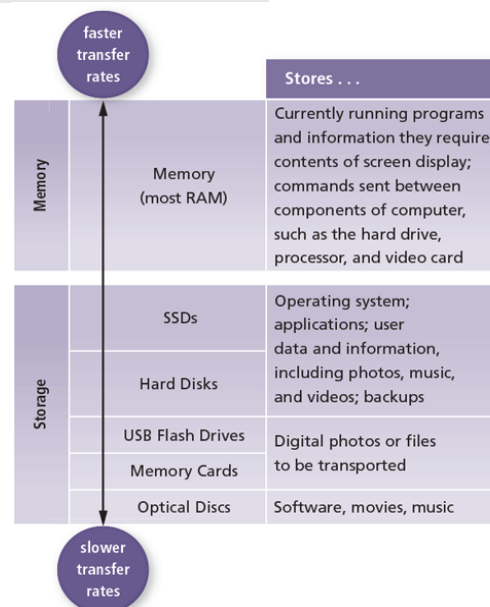


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## Types of Memory

1

### RAM (random access memory)

- Contents of RAM are lost when power is off (volatile)
- Temporarily store data required by the operating system and applications
- When the application is launched, the instructions of the application are transferred from the hard drive to the RAM

### ROM (read-only memory)

- Contents of ROM are NOT lost when power is removed (nonvolatile)
- The ROM chip contains the BIOS (instructions to start a computer)
  - Power-on self test: Test whether all computer components are ready
- ROM provides means to communicate b/t operating system and hardware devices
  - Firmware: low-level control for a device's specific hardware
  - Updated firmware version allows you to fine-tune the communication with other devices
    - Programmable ROM is used in smartphones and other mobile devices

## Common Types of RAM

1

Type of RAM	Description	Volatile or nonvolatile
<b>Dynamic RAM (DRAM)</b>	The memory needs to be constantly charged or the contents will be deleted	Volatile
<b>Static RAM (SRAM)</b>	The memory charge frequency may be less than DRAM, but can be more expensive than DRAM	Volatile
<b>Magnetoresistive RAM (MRAM)</b>	Memory uses magnetic charges to store contents, and can retain its content without power	Nonvolatile
<b>Flash memory</b>	The fast type of RAM is generally cheaper than some other types of RAM and can retain its contents without power	Nonvolatile



## Virtual Memory

1

Running more applications at the same time will require more RAM

- Exchange the content b/t RAM and hard drive
- **Virtual memory** is a part of a storage medium that acts as additional RAM
- The area of the hard drive used for virtual memory is called a **swap file**
  - **Swap** (exchange) data b/t memory and storage
- **Page** is the **amount of data** that can be exchanged at a given time
  - Swapping items b/t memory and storage is called **paging**
- **Thrashing** operating system spends lots of time paging instead of executing the application

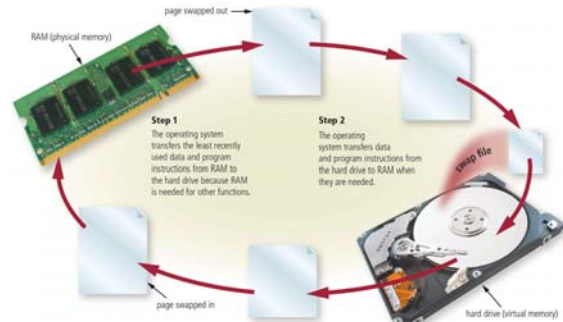
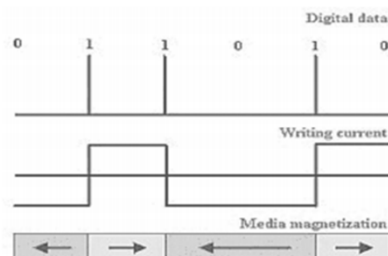


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

## Hard Drives

1

- **Hard disk** or hard disk drive (HDD) contains one or more non-fixed, circular platters which use magnetic particles to store data, instructions, and information



<https://www.youtube.com/watch?v=wteUW2sL7bc>

Step1. The circuit board controls the movement of the head actuator and a small motor

Step2. A small motor spins the platters while the computer is running

Step3. When software requests disk access, the read/write heads determine the current or new location of the data

Step4. The head actuator positions the read/write head arms over the correct location on the platters to read or write data



Photo by Frank R. on Unsplash

## Binary System- 0 & 1

1

How computers represent data

- 0 (false: absence) vs. 1 (true: presence)
  - Bit (binary digit): the smallest unit of data a computer can process
  - Byte: 8 bits form a byte, representing a single character in the computer
- Coding scheme: transfer a char into bits and bytes
  - ASCII: 8-bit coding scheme, 8 bits are used to represent letters, mathematical operators, etc.
  - Unicode: 16-bit coding scheme, extension of ASCII, support more than 65000 symbols and characters, including Chinese, Japanese, Arabic, etc.

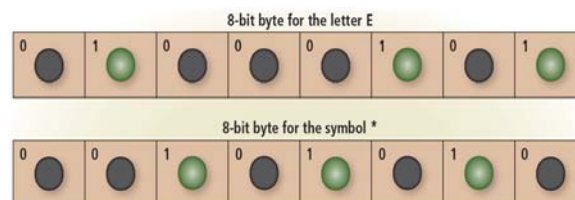


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

## Characteristics of Hard Disk

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- Before reading from or writing on a hard disk, the disk must be formatted
  - **Formatting**: the process that dividing the disk into **tracks** and **sectors**
- **Track** is a narrow recording band that forms a full circle on the surface of a disk
  - **Cylinder**: tracks that line up on each platter from top to bottom and can be read at the same time
- Breaking the tracks into small arcs called **sector**
  - A sector stores up to 512 bytes of data
  - Several sectors ( $n > 1$ ) form a **cluster**
- When a computer is running, the platters in the HD rotate at high speed; this rotational speed is called **revolutions per minute (RPM)**
  - 5400 rpm to 15000 rpm

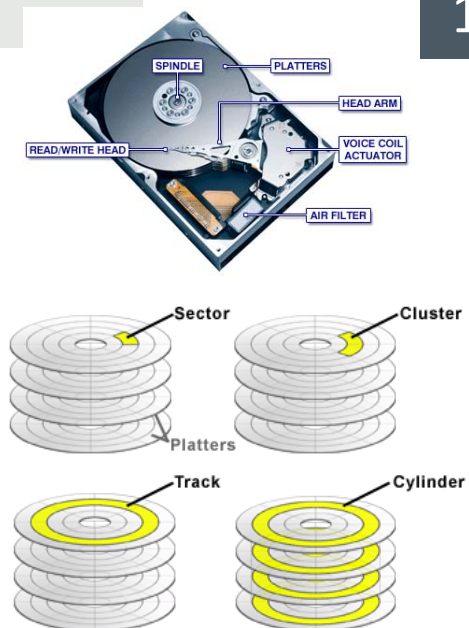


Photo credit: <https://goo.gl/images/3vuj6n>  
 Phot credit: <https://goo.gl/images/hyMSA1>

## Solid State Drive (SSD)

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**SSD (solid state drive)** is a flash memory storage device that contains its own processor to manage its storage

- An SSD has several advantages over traditional (magnetic) hard disks:
  - Faster access times
  - Faster transfer rates
  - Quieter operation
  - More durable
  - Lighter weight
  - Less power consumption
  - Less heat generation
  - Longer life
  - Defragmentation not required

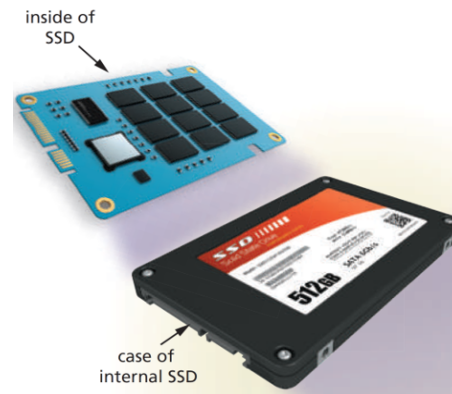


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## Cloud Storage

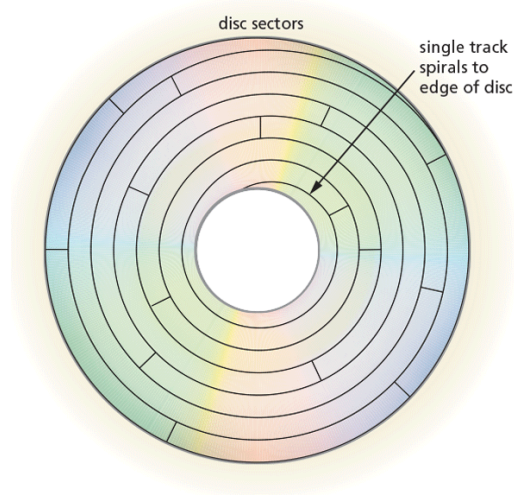
**Cloud storage** : An Internet service that provides storage to computer or mobile device users



iStockphoto.com / Aaltazar

## Optical Discs – Track and Sector

- Optical discs commonly keep items in a single track that spirals **from the center of the disc to the edge** of the disc
- Track is divided into equally sized sectors



## Types of Optical Discs

**CD-ROM:** can be read from but not written to

— Single-session disc

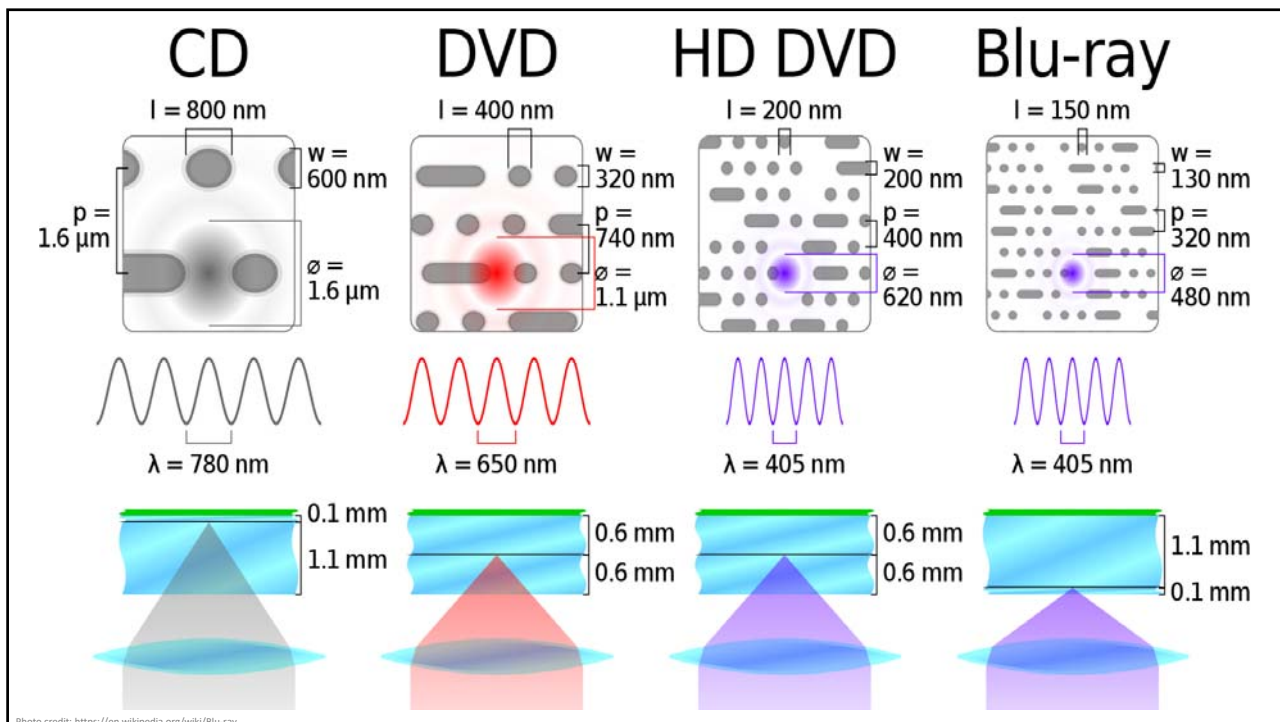
A **DVD-ROM:** a high-capacity optical disc on which users can read but not write on or delete

**CD-R :** an optical disc that users can write once, but not erase

A **DVD-R** or **DVD+R:** competing DVD-recordable WORM (write once, read many) formats, on which users can write once but not erase

**CD-RW:** an erasable multisession disc

**DVD-RW, DVD+RW, DVD+RAM:** competing DVD-rewritable formats that users can write on multiple times

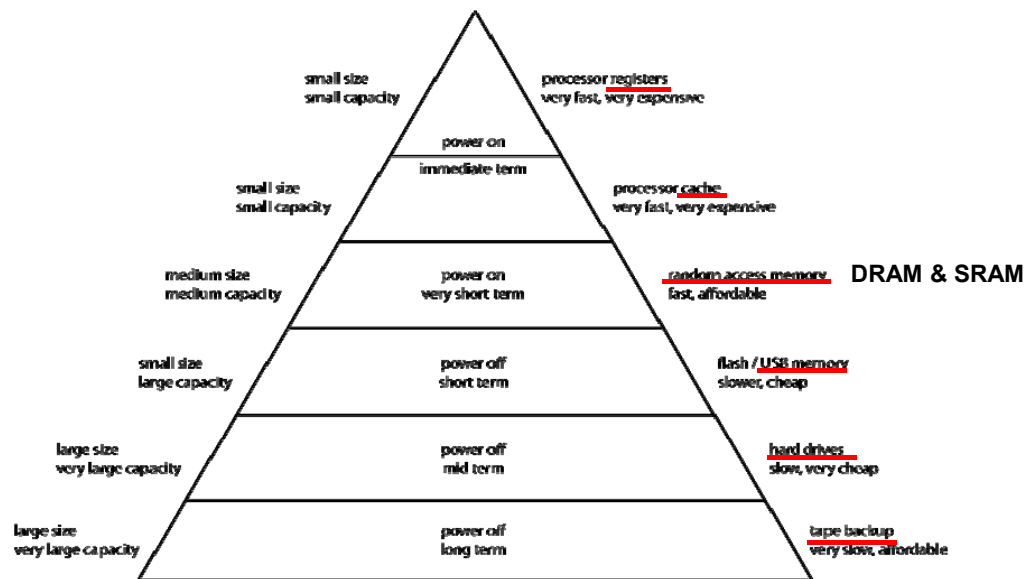


Parameter	CD	DVD	BD
Disk diameter	120 mm	120 mm	120 mm
Disk thickness	1.2 mm	1.2 mm	1.2 mm
Laser wavelength	780 nm	650 nm	405 nm
Numerical aperture	0.45	0.60	0.85
Minimum pit length	0.83 $\mu\text{m}$	0.4 $\mu\text{m}$	0.138 $\mu\text{m}$
Data rate	1.2 Mb/sec	11 Mb/sec	36 Mb/sec
Number of data layers	One	One or two	One or two
Data capacity	~680 MB	4.7 GB 8.5 GB	25-27 GB 50-54GB

Source: <https://www.slideshare.net/apurvapatilpatil/blu-ray-disc-61719679>

## Computer Memory Hierarchy

1



29

## What Is Input?

- **Input** : any data and instructions that entered into the memory of a computer

- Keyboard
- Pointing device
  - Mouse
  - Touchpad
  - Trackball
- Touchscreen/multitouch screens
- Pen Input
  - Digital pen
- Microphone
- Cameras/webcams
- Scanner



Image by [Free-Photos](#) from [Pixabay](#)

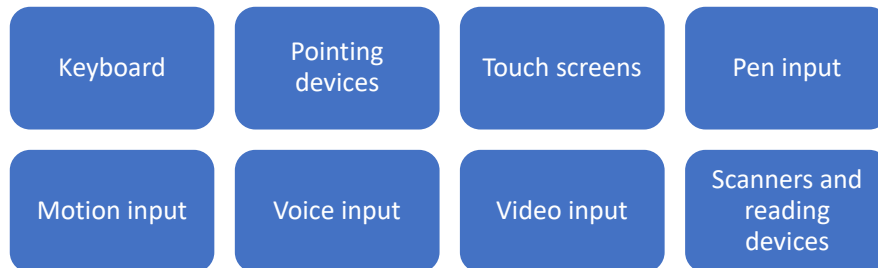


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## Input Devices

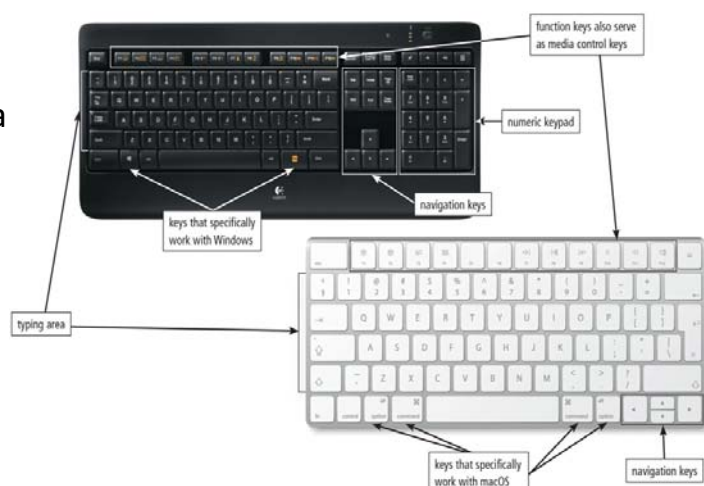
- Input methods that are commonly used :



## Keyboards

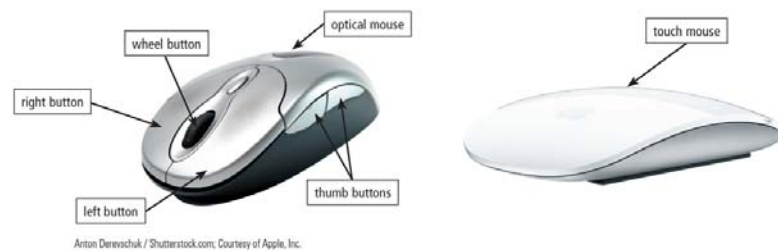
**Keyboard:** an input device that contains keys which you can press to enter data and instructions into a computer or mobile device

- Toggle key: switch between two states (Caps Lock, Num Lock, etc.)

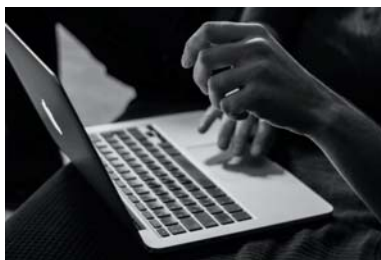


## Pointing Devices I

- **Pointer**: a small symbol on the screen whose location and shape change while a user moving a pointing device
- **Mouse** : A pointing device which fits under the palm of your hand comfortably
  - Optical mouse, laser mouse, and touch mouse



## Pointing Devices II



**Touchpad**: small, rectangular pointing device which is sensitive to pressure and motion



<https://www.logitech.com/zh-tw/product/ms-ergo-wireless-trackball-mouse>

**Trackball**: stationary pointing device with a ball on the top or side

## Pen Input

- With **pen input**, you can use a **stylus** or **digital pen** on a flat surface to write, draw, or make selections



## Graphics Tablet

- A **graphics tablet**, named a digitizer as well, is an electronic plastic board that detects and exchanges movements of a style or digital pen into signals that are sent to the computer



Photo by [CHARLI](#) on [Unsplash](#)

## Motion Input

### Motion input

- Gesture recognition
- Users can guide on-screen elements using air gestures

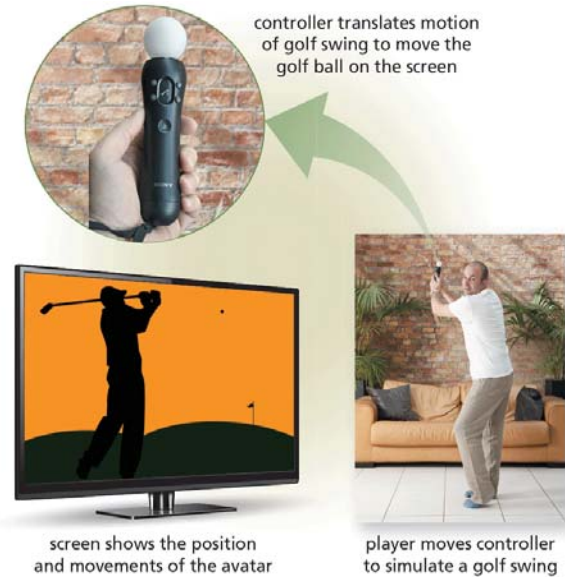
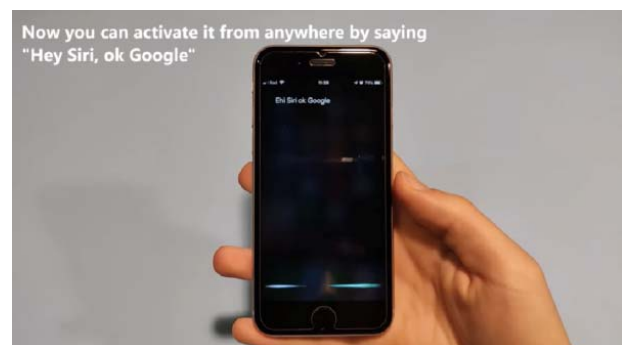


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## Voice Input

- Voice input : the process of entering input by speaking into a microphone
- **Voice recognition** (speech recognition) : The computer or mobile device's capability of distinguishing spoken words



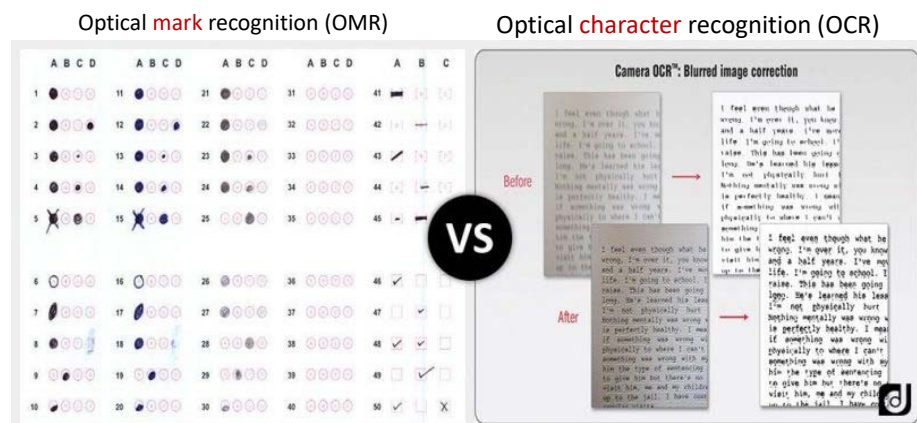
<https://3edition.com/brands/apple/5901>

## Scanners and Reading Devices

- A **scanner**: a **light-sensing** input device that converts printed text and graphics into a form the computer can process
  - The flatbed scanner works as a copy copier, except that it creates document files in memory instead of paper copies

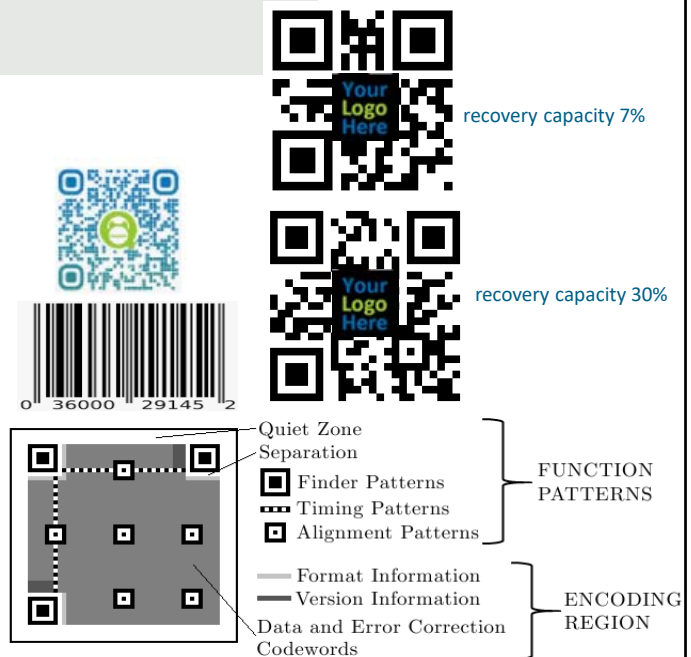
## Optical Readers

- An optical reader : a device that uses a light source to read characters, marks, and codes and then changes them into digital data that a computer can process



## Bar Code Readers

- **Bar code reader**(bar code scanner) : uses laser beams to read **bar codes**
- **QR (quick response) code** : keeps information in both a vertical and horizontal direction
  - Error correction level
  - Recovery capacity (%)



Video: <https://www.youtube.com/watch?v=L4YNWUJD8Do>

Photo: [https://www.researchgate.net/figure/QR-code-version-7-structure\\_fig1\\_304614728](https://www.researchgate.net/figure/QR-code-version-7-structure_fig1_304614728)

QR code generator: <http://qr.calm9.com/tw/>

## RFID

**RFID** (radio frequency identification) : uses radio signals to communicate with a tag placed in or attached to an object

**RFID reader** : reads information on the tag via radio waves

Tracking times of runners in a marathon

Tracking location of people and other items

Checking lift tickets of skiers

Gauging temperature and pressure of tires on a vehicle

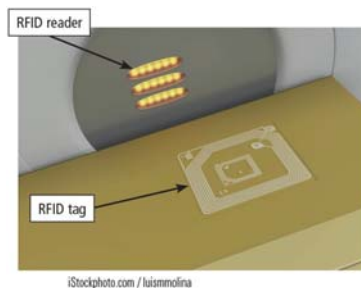
Checking out library books

Managing purchases

Tracking payment as vehicles pass through booths on tollway systems

## RFID

- **RFID tag** : consists of an antenna and a memory chip that contains the information to be transmitted via radio waves
- RFID reader reads radio signals and transmits the information to a computer or computing device



iStockphoto.com / luismolina

## NFC

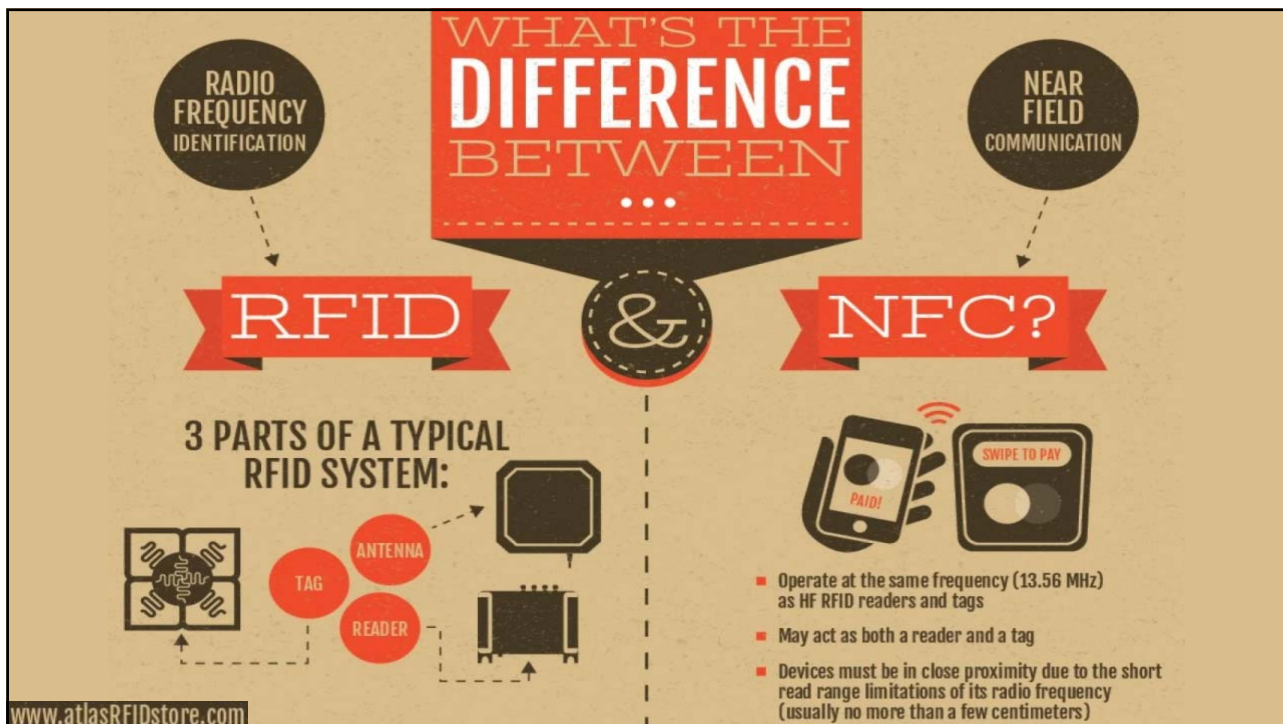
An NFC-enabled device contains an NFC chip

- An NFC tag contains a chip and an antenna that contains information to be transmitted



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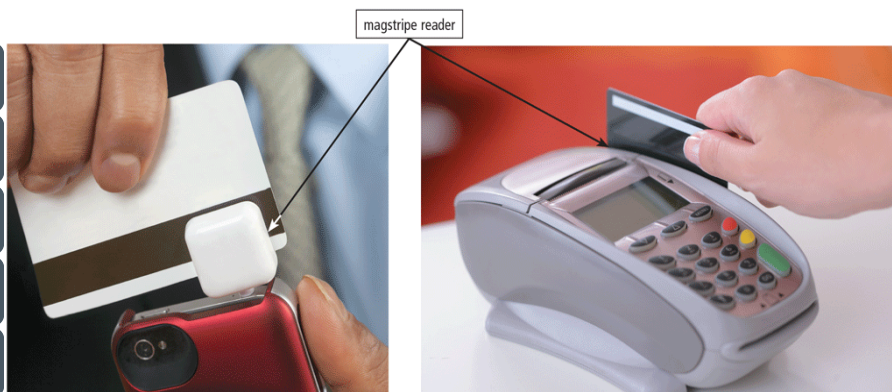




## Magstripe Devices

Read the magnetic stripe on the back of cards such as:

- Credit cards
- Entertainment cards
- Bank cards
- Identification cards
- Other similar cards



EdBockStock / Shutterstock.com; iStockphoto.com / hocus-focus

## Card

- A **magnetic stripe card** has a magnetic stripe that contains information
- A **smart card** keeps data on an integrated circuit embedded in the card



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## What Is Output?

Data that processed into a useful form

- Speakers
- Headphones
  - Earbuds
  - Headsets
- Projectors
- Voice synthesizer
- Printers
  - Ink-jet
  - Laser
  - Multifunction device (MFD)
  - Mobile
  - Plotter
  - 3-D



Image by [Michal Jarmoluk](#) from [Pixabay](#)

## Displays

- **Display:** visually conveys text, graphics, and video information
- **Monitor:** a display that is packaged as a separate peripheral device
  - **LCD monitor**

laptop display

Photo by [Kari Shea](#) on [Unsplash](#)

Digital camera display

Photo by [ShareGrid](#) on [Unsplash](#)

Digital camera display

Photo by [Oskar Kadaksoo](#) on [Unsplash](#)

handheld game device display

Photo by [Ben](#) on [Unsplash](#)

Smartphone display

Photo by [Jonathan Kemper](#) on [Unsplash](#)

Monitor display

Photo by [Kitai Jogia](#) on [Unsplash](#)

## Display Ports

- The monitors today use a digital signal to produce a picture
- The monitor should plug in display ports to display the highest quality images:
  - VGA port
  - DVI port
  - HDMI port
  - DisplayPort

More details: <https://www.youtube.com/watch?v=3LoGJZmyfPA><http://www.brucebnews.com/2014/08/the-confusing-world-of-video-vga-dvi-hdmi-displayport/>

## Digital Television

- Home users sometimes use a digital television (DTV) as a display
- **HDTV** (High-definition TV) is the most advanced form of digital television
  - Provide higher resolution images
- Smart TV is a high-definition TV that supports the Internet



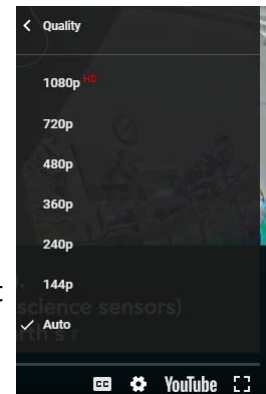
Photo by [Glenn Carstens-Peters](#) on [Unsplash](#)

## Quality of Displays

- The quality of a display depends primarily on its:
  - **Resolution:** number of horizontal and vertical **pixels** in a display
  - **Response time:** the time required to turn the pixel on or off (in milliseconds)
  - **Brightness:** measured in nits (nits: a unit of visible light intensity, equal to one candle per square meter)
  - **Dot pitch:** also called pixel pitch, the distance between pixels on the display, in millimeters
  - **Contrast ratio:** difference in light intensity between the brightest white and the darkest black that can be produced on the display
  - **Frame rate:** Frames per second (fps), expressed in Hertz, the frequency at which successive images called frames appear on the display
    - The human visual system can process 10 to 12 images per second and perceive them separately, while higher rates are considered motion

## How Computers Represent Images

- Pixel: the smallest picture elements
  - Each color is assigned to a binary number: white: 11, black: 00
- The resolution of the video file is width x height; the higher the resolution, the clearer the video
  - Standard definition (SD): 640 x 320 and 720 x 480
  - High definition (HD): 1280 x 720 (720p) and 1920 x 1080 (1080p or Full HD)
  - 4K: 3840 x 2160 (2160p)
  - 8K: 7680 x 4320 (4320p)
  - Not all devices can play 4k/8k files. Play 4k video on 720p display, your computer will convert 4k video to 720p, because this is the best video the screen can provide



## Common graphics file formats

Graphic file format	File extension	Best use / Notes
<b>Bitmap graphics</b>		
GIF	.gif (Graphics Interchange Format)	Simple web graphics and short web animations Format is limited to 256 colors; supports transparency; small file size makes it good for websites
JPEG	.jpeg or .jpg (Joint Photographic Experts Group)	Photos on the web Images have rich colors, but discard some data to reduce file size, which can affect quality
PNG	.png (Portable Network Graphics)	Logos, icons, and illustrations Images have good quality even when highly compressed; supports 16 million colors; better quality and smaller file size than GIF
TIF	.tif or .tiff (Tagged Image File Format)	High-quality photos and printed graphics Large file size is better suited for print than web use
<b>Vector graphics</b>		
EPS	.eps (Encapsulated PostScript)	Logos and other illustrations that are frequently resized A standard format for exporting vector graphics without data loss
SVG	.svg (Scalable Vector Graphics)	Illustrations on the web Developed by the World Wide Web Consortium (W3C); allows interactivity and animation

## Printers

- A printer is an output device that generates text and graphics on physical media
- Before buying a printer, ask yourself a series of questions



攝影師：[cottonbro](#)，連結：[Pexels](#)

## Printers

**Nonimpact printer:** forms characters and graphics on a piece of paper without actually contacting the paper

Type of printer	Description
<b>Ink-jet printer</b>	Prints by spraying small dots of colored ink onto paper
<b>Laser printer</b>	Uses a laser beam and toner to print on paper
<b>Multifunction device (MFD)</b>	Also called an all-in-one printer; can serve as an input device by copying and scanning, as well as an output device by faxing and printing
<b>Mobile printer</b>	Small, lightweight printer that is built into or attached to a mobile device for mobile printing
<b>Plotter</b>	Large-format printer that uses charged wires to produce high-quality drawings for professional applications such as architectural blueprints; plotters draw continuous lines on large rolls of paper
<b>3-D printer</b>	Creates objects based on computer models using special plastics and other materials



## Ink-jet Printer

- An **ink-jet printer** forms characters and graphics by ejecting tiny liquid ink drops onto a sheet of paper
  - Color or black-and-white
  - Speed is measured by the number of pages per minute (ppm) it can print



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## Laser Printer

Laser printer

- High speed
- Black-and-white/color
- High quality



Courtesy of Xerox Corporation



## All-in-one Printers

- An **all-in-one printer** : a single device which can *print, scan, copy, fax* (multifunction printer)



## Mobile Printer

- The **mobile printer** :  
a small, lightweight, battery-powered printer that allows mobile users to print from mobile devices



Courtesy of Brother International Corporation

## Thermal Printer

- **thermal printers** : generates images by pushing electrically heated pins against the heat-sensitive paper
  - Dye-sublimation printer



## Plotter

- **Plotters** : produce high-quality drawings
- **Large-format printers** :  
create photo-realistic quality color prints



## 3-D Printer

- **3-D printer** : use a process called additive manufacturing to create objects by adding materials to a three-dimensional object, one horizontal layer at a time



Photo by [Tom Claes](#) on [Unsplash](#)

## Projector

- A **data projector** is a device that projects text and images displayed on a computer or mobile device screen onto a larger screen so that the audience can see the image clearly



Image by [Michal Jarmoluk](#) from [Pixabay](#)

## Interactive Whiteboard

- An **interactive whiteboard** is a touch-sensitive device similar to a dry-erase board that can display images on a connected computer screen



[QOMO 107" 16:9 IR Interactive Whiteboard](#)

## Assistive Technology Input and Output



**Figure 7-44** A camera/receiver mounted on the monitor tracks the position of the head-mounted pointer, which is the reflective material on the brim of the hat. As the user moves her head, the pointer on the screen also moves.  
Courtesy of NaturalPoint, Inc.



**Figure 7-45** A Braille printer.  
Courtesy of Enabling Technologies, Don Farrell / Getty Images