



# **VIQC Elementary School**

## **Reverse Engineering Online Challenge**



### **Disassembling and Analyzing a Toshiba Portege M600**

#### **Laptop**

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# Summary Report

Over the decades, technology has advanced by leaps and bounds, in different varieties and shapes. When it comes to high tech devices, objects that appear to mind include iPads, phones, laptops, computers, and smart appliances. The latest inventions are even more fascinating and appealing. So when our team was offered an old camera, 2 fans, a heater, hair dryer, and a 2007 Toshiba Portege M600 laptop, our eyes immediately landed on the silver laptop. We all knew that this was our chance to investigate the past, present, and future of our world.

Once the laptop was opened, we saw dozens of features inside. In order to obtain more data, we asked ourselves: What is this? Where is it placed? Why is it here? And how does it work? This was our methodology for disassembling and analyzing each element of the laptop. Whenever possible, we snatched the opportunity of performing additional study and analysis.

Through research, we learned about the motherboard, monitor, keyboard, and many internal components. All this data led us to figure out the main mechanisms that are needed for a basic computer system. We determined that the major parts were the CPU (central processing unit), two batteries, screen, storage space (hard drive or solid state drive), RAM (random access memory), and the graphics card. The CPU acts as the brain, while the other components function like organs. The motherboard is like the backbone, holding the components in place, and connecting all the parts with pins and cables. When each element does its duty, the system functions like the laptop we know.

The highlights of this project were the examinations and deeper analyses we did on the Li-ion Battery Pack, heatsink, and CMOS BIOS button. Unfortunately, due to safety concerns and a lack of testing materials, some studies could not be conducted and many elements were not identified. For example, on the search for the BIOS chip, we noticed that there were tons of small, identical, and unmarked chips on both the motherboard and circuit boards. We pondered on which one it could be. According to earlier research, the chip was attached to eight pins. Yet many chipsets were similar. We also noticed tiny, white codes embedded on the circuits. The most common began with T, R, C, and D. At this stage, we know what they are called but we do not completely understand what they do and how they work.

Letter	Meaning
T	Transformer
R	Resistance
C	Capacitance
D	Diode

When we discussed what to do with the remains of this laptop, we were delighted to learn that 98% of the parts are recyclable. The recyclable pieces include the battery pack, power supply, display, motherboard, and the plastic casing of the whole laptop. Shockingly, we discovered on YouTube that people could extract gold from the RAM, HDD, and CPU! We were happy to know that what we went through and remains will not go to waste, but be recycled to save our environment.

(496 words)

# Parts List



1- Monitor Case

2- Monitor

3- DVD Player

4- Motherboard

5-SSD (Solid-State-Drive)

6- Li-Ion Battery Pack

7- Circuit Board

8- Keyboard

9- Lid (RAM)

10- Dummy cover

11- HDD Bracket

12- Lid(HDD/SSD)

13-Fingerprint-Scanner

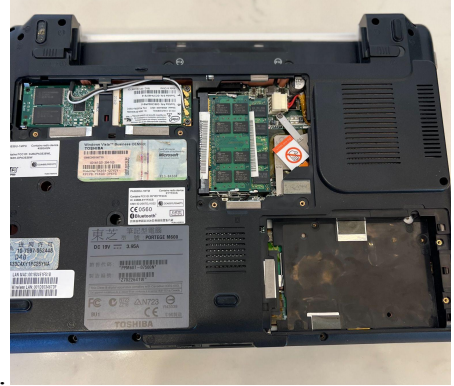
## Introduction

### Laptop-

The laptop we chose for the Reverse Engineering Online Challenge is the Toshiba Portege M600. This laptop is now discontinued, meaning it isn't sold by Toshiba anymore. It is about 16 years old.

# Disassembly Procedure

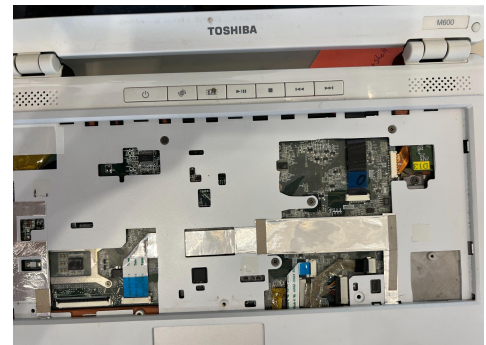
1. We turned to the backside and took off the cover for the RAM, and the turbo memory. We also took out the SSD.



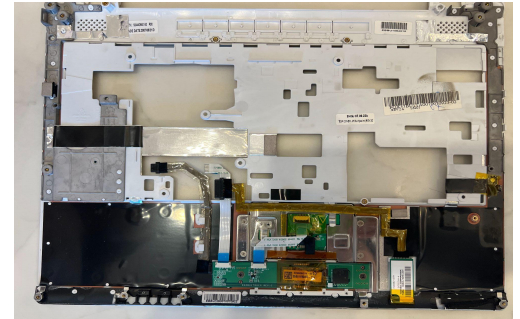
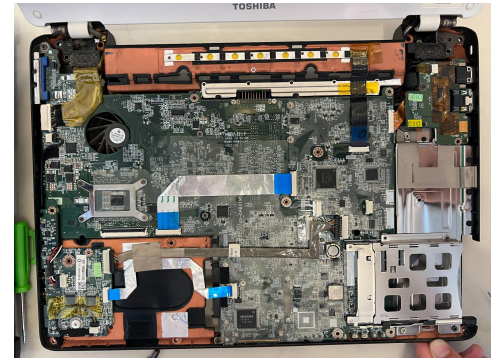
2. We did some research and found out that the black caps (like F3) can be taken off. Then, we unscrewed the rest of the screws and took out the DVD player.



3. We removed the keyboard and took out the screws on the bottom of the keyboard.



4. We lifted the top cover to find the motherboard. On the top cover, there was a fingerprint scanner and a mouse.



5. We took out the flexible flat cables (FFC) and some more screws to get the motherboard.



6. Similarly, we took apart the monitor panel.





# Research Findings

## I. Key Components

### LCD Monitor

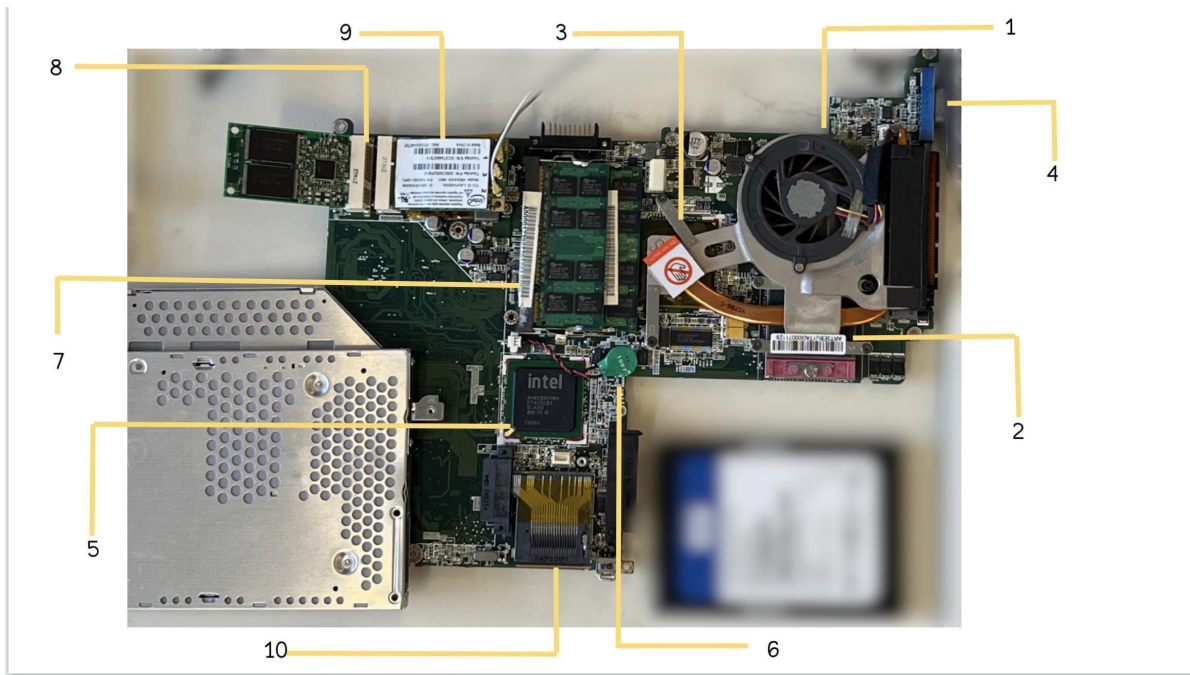


**Monitor is an output device that displays information in pictorial or textual form.**

- B133EW01
- This monitor's active area is 286.08 x 178.8 mm and is an LCD (Liquid Crystal Display) monitor.
- According to TechTarget, LCD works on the principle of blocking light instead of emitting light. LCD produces images using backlight and they use less energy than LEDs.
- One big con is they produce a light that harms the eyes and you have a limited angle to view your LCD screen.

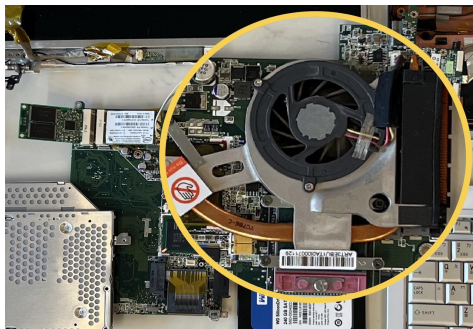
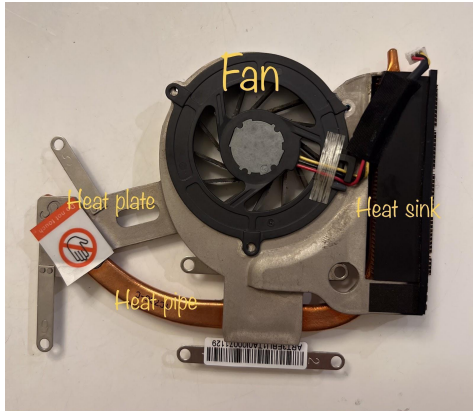
# Motherboard

The motherboard acts like the backbone of the whole laptop. There are a lot of components on this multiple-layer circuit board. For example, the CPU, GPU, other chipsets, different kinds of connectors, a bulk of surface-mounted resistors, diodes, and capacitors. Through the process of researching, we have come across many unmarked items, because they are hard to identify.



Front of the Motherboard

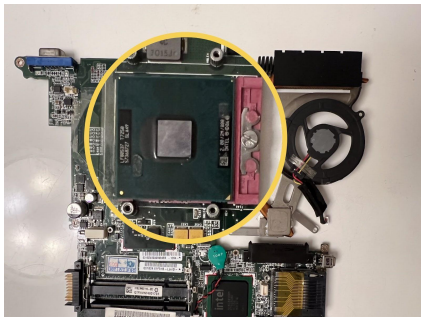
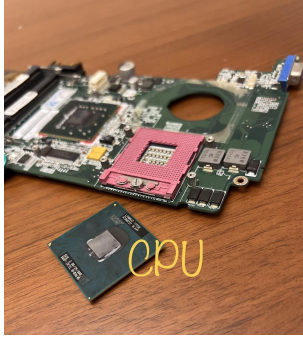
# 1. Cooling system



**The Cooling System has a fan, a large custom-made metal plate, a heat sink, and a heat pipe all from aluminum, or copper.**

- The cooling system rests on top of the CPU and the GPU
- It helps to avoid the two chips from getting overheated
- The heat generated from the CPU and GPU, will transfer to the heatsink through the heat pipe, and dissipate away with the running fan.
- The copper heatsink has fins to increase the surface area for more heat to come in
- This heatsink lets other devices be reliable, and it also prevents failure in components
- Beware of the heat plate while normal operation

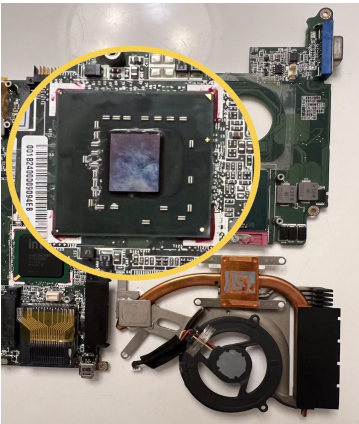
## 2. CPU



**The CPU stands for Central Processing Unit.**

- The CPU is placed on a socket, and under a heat plate
- It is the powerful brain of the computer
- With the software instructions, it interprets, executes, and communicates with other hardware
- The CPU is normally 60-80 Celsius for regular use, but it can shoot up to 90-95 if you are doing deep work

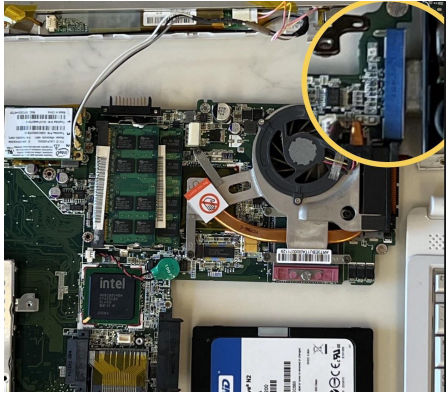
## 3. GPU



**The GPU stands for the Graphics Processing Unit / Graphics Media Accelerator ( GMA )**

- The GPU is an integrated Graphic chip
- It uses accelerated calculations to generate a high-resolution image, and graphics
- It divides tasks into smaller sub-tasks that are distributed among a large number of processor cores inside ( Parallel processing )
- This GPU gets to 35-60 Celsius, while thorough use it can spiral to 60-80 Celsius

## 4. VGA Connector



**The VGA Connector stands for Video Graphics Array / Video Graphics Adapter**

- The processed video from the GPU can be displayed on the laptop's screen
- It can also show on the external monitor, through the VGA connector
- The VGA is a computer output port, used to connect peripheral devices for transferring video signals only

## 5. ICH



**The ICH is an I/O Controller Hub**

- It provides a point-to-point connection between different components on the motherboard
- It speeds up the data transmission between the CPU and other chipsets

## 6. CMOS BIOS Button Battery

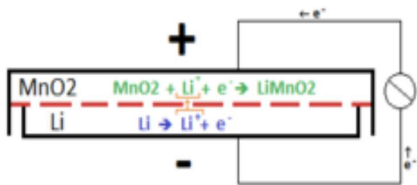
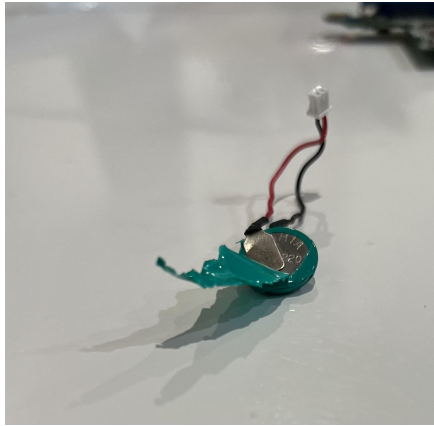
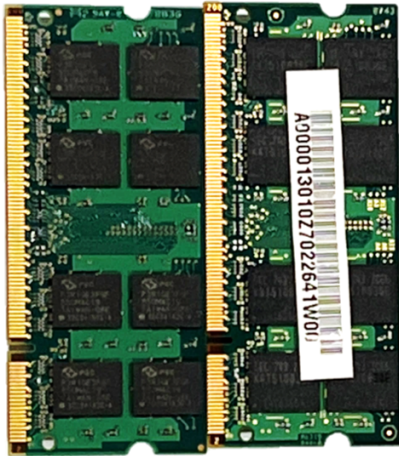


Diagram of lithium button cell battery with  $\text{MnO}_2$  (manganese dioxide) at cathode.

**The lithium alloy/manganese dioxide battery was created by Varta in Germany.**

- CMOS is the Complementary metal-oxide-semiconductor
- BIOS means Basic Input/Output System (The BIOS chip is used to store the hardware configuration setting for booting but it is too hard for us to identify this chip due to its size)
- The battery is protected by a green cover
- It works even when the laptop is turned off. If the device is shut down for days, the date and time will still be accurate
- Its function is to track the time and date, a system named Real Time Clock {RTC} and enable the booting process.
- CMOS battery life depends on the usage of the device. The less the laptop is being used, the faster the battery will die out
- Usually it lasts for about 10 years
- Sadly, this circular battery cannot be recharged

## 7. RAM (Random-access Memory)



**SRAM (static RAM) is a type of random access memory (RAM)**

- It is connected to the computer through RAM slots
- Eight integrated chips on each side of the circuit board with a tiny chip called the Serial Presence Detect
- DRAM is usually arranged in a rectangular array of charge storage cells consisting of one capacitor and transistor per data bit
- RAM usually connects to the device's motherboard and is a type of memory. This one is a Samsung® 2GB DDR2 800MHz memory and PSC 2GB DDR2 800MHz memory
- RAM is a form of computer memory that can be read and changed in any order, typically used to store working data and machine code

## 8. Intel® Turbo Memory



**Intel Turbo Memory is a module which use to enhance OS system efficiency**

- It is attached to the motherboard by the Flash Cache Logic Slot
- Intel® Turbo Memory is a technology introduced by Intel Corporation that uses NAND flash memory modules to reduce the time it takes for a computer to power up, access programs, and write data to the hard drive. In this laptop, there are two Intel Turbo Memories

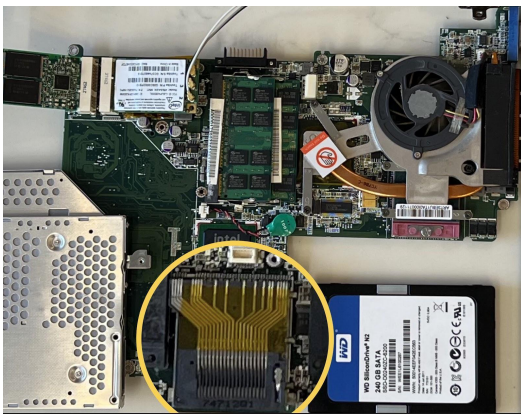
## 9. Wifi/Bluetooth Adapter



**The wifi/bluetooth adapter make laptop connect to network/other device without wire cable**

- A Wireless Fidelity (Wifi) card is a high-speed internet connection and network connection without the use of any cables or wires.
- The wireless network operates three essential elements that are radio signals, antenna, and router.
- Wi-Fi cards are the receiver of radio signals.
- There are three antennas for the wifi card to improve and stabilize the wifi connection. The card is behind the Monitor.
- Bluetooth is a technology that allows people to communicate through long distances without any cables.

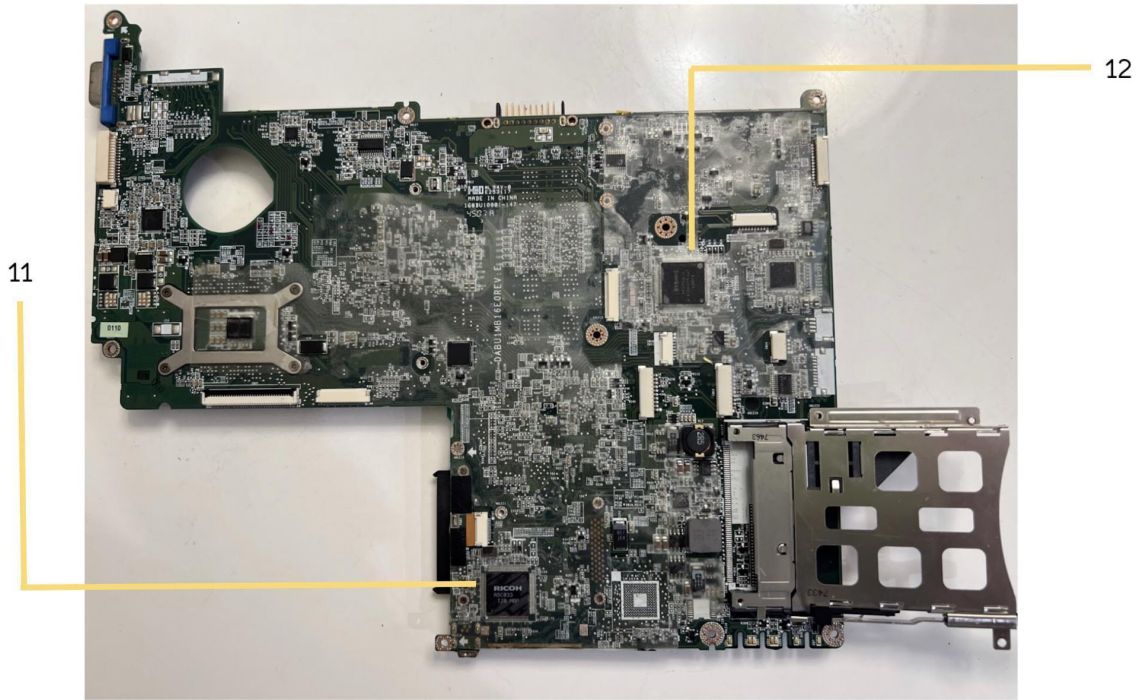
## 10. Multiple Digital Media Card Slot



**When the card is inserted into the Multiple Digital Media Card (MMC) Slot, files are uploaded onto the laptop.**

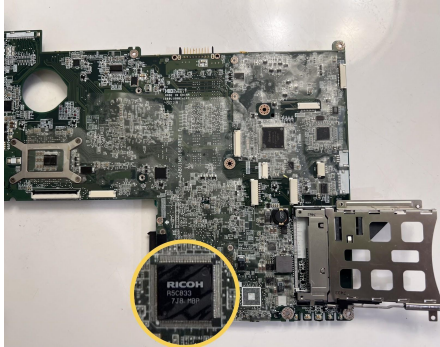
- The Multiple Digital Media Card is a secure digital storage device
- The MMC card can hold a tremendous amount of information like images, videos, audio, and text files





Back of Motherboard

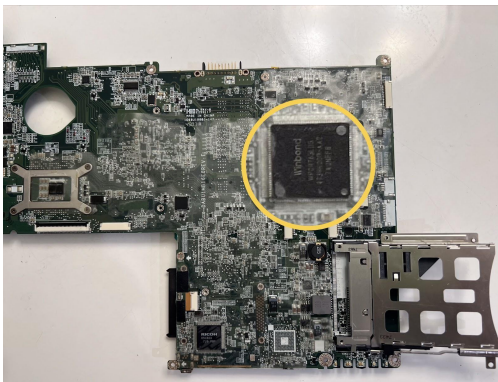
# 11. Memory Card Host Controller



**The Memory Card Host Controller comes from the company Ricoh**

- In a computer hardware system there are hosts or masters, and slaves, the masters give orders to the slaves
- In this case the Memory Card Host Controller acts as a host, it gives instructions to other hardware (Flash memory Cards)
- The laptop will use the Memory Card Host Controller to access, read and write to the memory cards connected through it.
- The Memory Card Host Controller is below the Multiple Digital Media Card Slot, where the Multiple Digital Media Card (MMC) can be inserted
- This controller transfers data from the system memory to MMC and vice versa.

# 12. Embedded Controller



**The Embedded Controller is also known as EC**

- The Winbond WPC8763L is a highly integrated embedded controller ( EC ) with a RISC core and integrated advanced functions
- These functions include Watchdog, PWM, Timers, system health monitoring, etc.

# SSD (Solid-State-Drive)



The SSD is used for memory, mainly used in personal devices (laptops, phones, etc.).

- It is a newer, faster, more durable replacement of the HDD (Hard-Disk-Drives).
- Manufacturers create them by stacking different types of chips for different densities (organization of data storage).

## SSD HDD Comparison

SSD	HDD
<ul style="list-style-type: none"> <li>● Newer</li> <li>● Faster</li> <li>● No moving spins to store memory</li> <li>● More expensive</li> <li>● More durable</li> </ul>	<ul style="list-style-type: none"> <li>● Older</li> <li>● Slower</li> <li>● Has a moving spin to store data (higher chance of being broken)</li> <li>● Less durable</li> <li>● Less expensive</li> </ul>

## SSD PRO AND CONS

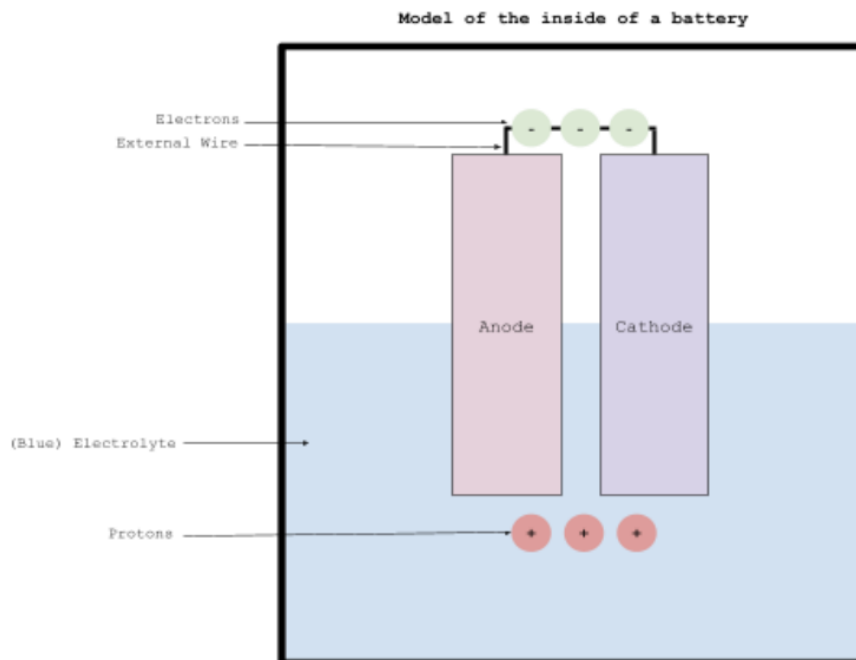
PRO	CON
<ul style="list-style-type: none"> <li>● Fast</li> <li>● Durable</li> <li>● Quiet</li> <li>● Doesn't need a lot of power consumption</li> </ul>	<ul style="list-style-type: none"> <li>● Expensive</li> <li>● Life expectancy (duration)</li> <li>● Normally sold in smaller sizes due to price</li> <li>● Bad Data Recovery</li> </ul>

# Li-ion Battery Pack



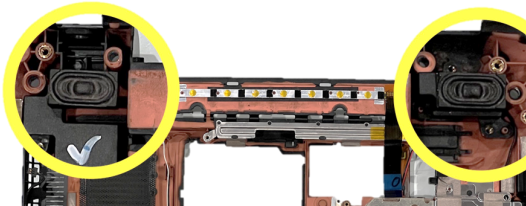
**Li-ion batteries are a type of battery that uses Lithium as a key component of it.**

- Li-ion batteries work by converting chemical energy to electricity.
- Each battery has 2 electrochemical cells (anode and cathode). An external wire and electrolyte are separating these 2 cells and protons (positively charged) and electrons (negatively charged) flow through the wire and electrolyte.
- (As Sample)  $3 \text{ protons} - 3 \text{ electrons} = 0 \text{ charge} = \text{balanced}$ .  
When it is balanced, electricity from the electrons flows through the wire and the battery activates.



# Sound System

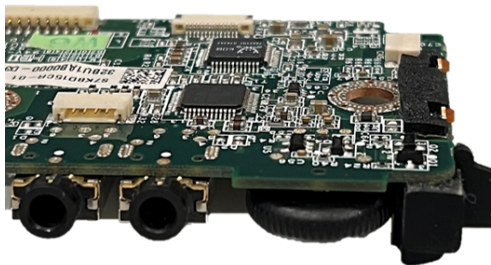
## 1. Speaker



**A computer speaker is an output hardware device**

- A computer speaker is an output hardware device that connects to a computer to generate sound. The speakers are built left and right to make a stereophonic sound. The speakers are connected to the audio card by cables/wires. Speakers are not a thing every computer has, but speakers are most likely needed

## 2. Sound Card

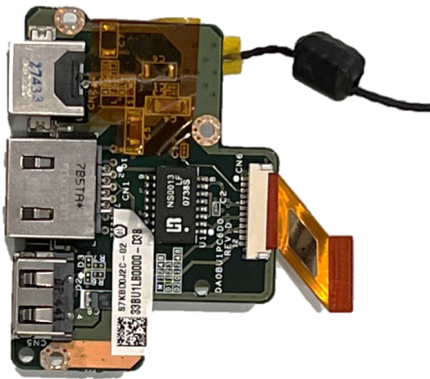


**A Sound card turn digital code to analog signal or turn analog signal to digital code**

- A sound card is a computer component that translates digital audio signals to analog signals and analog audio signals to digital ones.
- It is on the left bottom corner of the casing of the motherboard.

# Small Circuit Boards

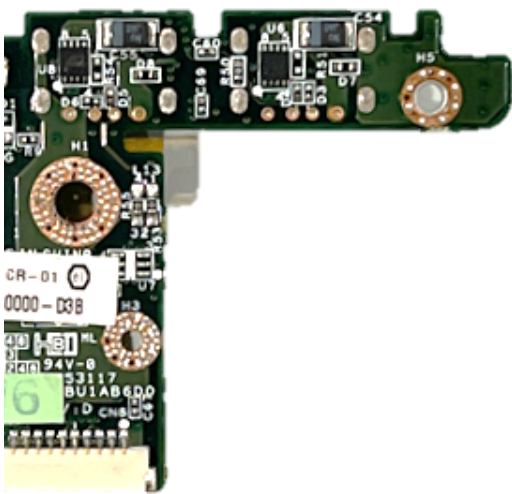
## 1. Ethernet/Modem Adapter



**A Ethernet/Modem adapter connect to network with ethernet cable/phone cable**

- Ethernet is a system for connecting several computer systems to form a local area network, with protocols to control the passing of information.
- The modem jack allows you to use a modular cable to connect the modem directly to a telephone line.
- Now, it is replaced with Cox, Google Fiber, etc.
- The Modem is located on the right side of the laptop along with the ethernet card.
- The outer casing also acts like a cooling system and cools off the inside components.

## 2. USB hub



**A USB hub use for connect multi usb device to laptop**

- A USB hub is a device that expands a single Universal Serial Bus (USB) port into several so that there are more ports available to connect devices to a host system, similar to a power strip.
- All devices connected through a USB hub share the bandwidth available to that hub. This is the same card as the audio card.

# Input Devices

## 1. Fingerprint Scanner



**A fingerprint scanner identifies a fingerprint and turns that data into a code.**

1. There are different types of fingerprint scanners and ours is an optical scanner. (Optical= relating to sight)
2. An optical scanner contains a light-sensitive microchip that analyzes the image (fingerprint).
3. The chip produces a digital image.
4. After analyzing, they use pattern-making software to turn it into code.

## 2. Keyboard shortcut



**Keyboard shortcut is a series of one of several keys to quickly invoke a software program or perform a preprogrammed action.**

- These keys are connected to the inner side of the case.
- These keys mean shut down/open, pause, play, next song, and song before. Some of them are unknown. These keys connect to the keyboard.
- When you press them the laptop processes them and shows them on your screen.

# 3. Keyboard



A keyboard is an important part of a computer that you can use to write an email, write a report, etc.

➤ How does it function?

1. When a keyboard is pressed, it pushes a rubber dome or spring inside the plunger downwards.
2. When pressed, it makes an electric contact. When 2 contacts come together, scanner identifies electricity flows through a circuit.
3. The circuit contains data on the type of key pressed. It goes to a chip called a microprocessor. It is a scan card. The data/signal from the circuit would match with the chip for the computer to identify what key was typed.
4. The microprocessor now passes the information to the RAM (information about the RAM in Motherboard).
5. The RAM now transfers this information to the monitor and the text character is now displayed.

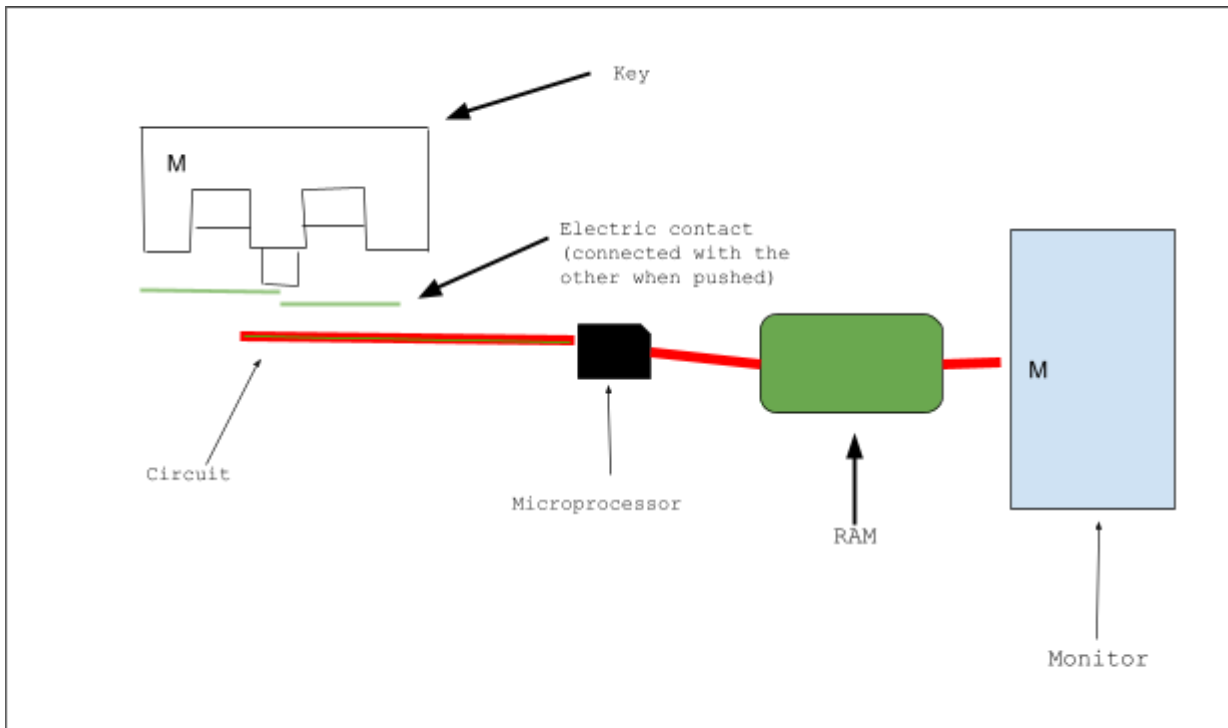
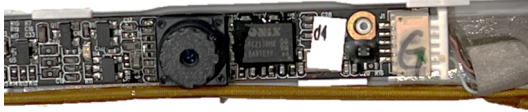


Diagram of a Keyboard functioning



## 4. Webcam



**A webcam is a video camera. It is like a live camera and can take photos**

- A webcam is a video camera. It is like a live camera and can take photos. Most laptops, computers, and iPhones have a webcam.
- The webcam of this laptop and most other laptops, is above the monitor.

## 5. Microphone



**A Microphone is an input device**

- A microphone is an instrument that turns sound waves into electrical energy variations which can be turned louder/quieter, transmitted, or recorded.
- The microphone is to the left of the webcam.

# DVD Player

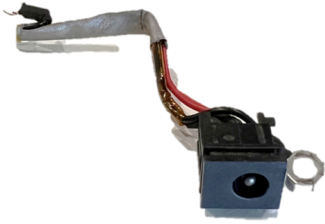


**A DVD player processes a DVD and either plays music or displays an image (for ex. A movie or a song you like).**

➤ How does it function

1. When a disc is inserted into a DVD player, the disc's track is scanned by a low-intensity infrared laser.
2. For a DVD player to keep scanning with a laser, a CD rotates.
3. When the light beam strikes land, it is reflected in a photodiode, and an electrical pulse is generated. When it strikes a pit, no electric pulse is generated.
4. A device known as a digital-to-analog converter translates the electricity to play the correct sound and corrects any data misreads from minor disk blemishes and imperfect laser alignment.
5. When an electric pulse is generated, we hear music from the electricity.

# Power Supply



**Power supply is an electrical device that supplies electric power**

- Wire with black power cord and ground Power supply
- The power cord and ground connect the electricity from the power supply to the motherboard and inside components.
- This component is under the speaker on the left.



## II. Deeper Analysis

### 1. Li-ion Battery Pack

A Li-ion battery is made out of lithium. It is made out of Li-ion, the 3rd element of the periodic table. It is alkali, meaning it reacts aggressively. Due to this reason, lithium is a commonly used metal in batteries. Since it reacts aggressively, lithium ions have higher voltage compared to other batteries and higher voltage stores more energy.

The image shows a standard periodic table of elements. The first column, labeled '1A' and 'ALKALI', is highlighted in pink. The element Lithium (Li) is circled in red within this column. The table includes element symbols, names, atomic numbers, and groups.

<b>3</b>
<b>Li</b>
6.941

#### Quick Facts about Lithium:

Atomic Number- 3 (3rd element in the periodic table)

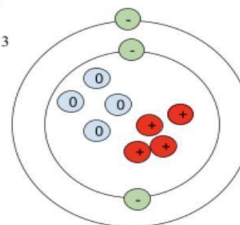
Atomic Mass- 6.941 (7)

Atomic Symbol- Li

(Green) Electrons- 3

(Red) Protons- 3

(Blue) Neutrons- 4

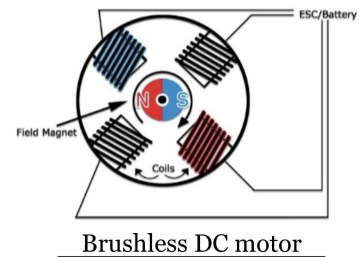
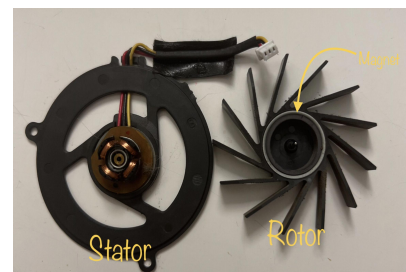
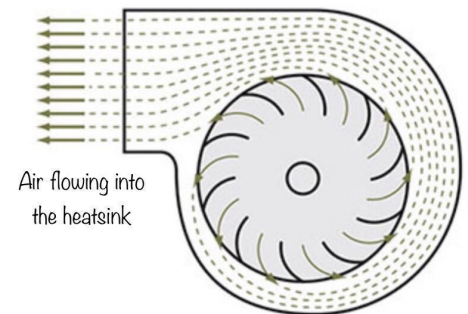
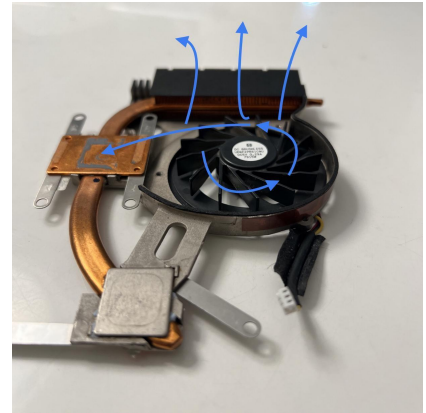


## 2. Cooling System

The computer is nothing without the cooling system. If it was left out, the CPU would overheat and overload. To further examine, we disassembled the cooling system and investigated the fan. Next, we experimented on the conductivity of heat by observing how the system responds to the temperature.

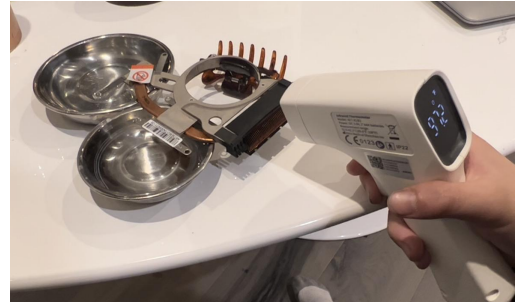
When at work, the fan will constantly spin at high speed. The cool air travels around. Some air will end up hitting the CPU, and others will be pushed out. It will pass through the heatsink. As the process continues, the heat in the heat sink comes out with the help of the cool wind.

The two basic things that make up the fan are the rotor, and the stator. When we opened up the fan, we saw the rotor with blades, and a magnet. Along with the DC motor on the stator. The brushless DC motor is more efficient. It's quieter, lighter, and has a longer lifespan. When a current starts, it creates an electromagnet which rotates the rotor to 360 degrees.



In a recent experiment, we proved that the cooling system has high conductivity while at work. The hot water in this test represented heat. In order to test the response, we heated up the GPU, and CPU heat plate with hot water, and we recorded the temperature of the heatsink every ten seconds.

When the heat plates first touched the hot water, the temperature of the heatsink was 97.2 F°.



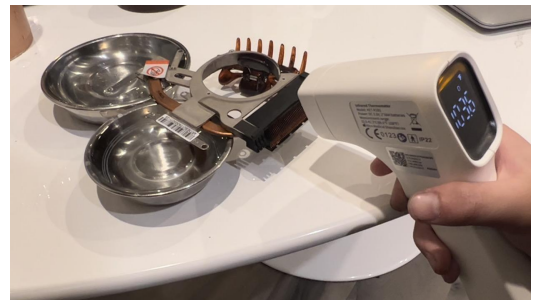
On the next check, the condition of the heatsink was 99.4 F°. We could feel the warm air coming out.



The third try spiraled up to 101.8 F°. The heat plate, and heat pipe had heat transferring through them.



Finally, the climate was boosted to 103.6 F°. The whole case was warm. Later, the temperature dropped because the heat from the water faded away.



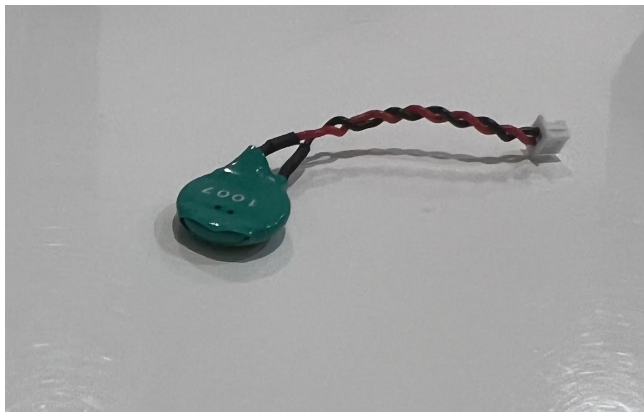
In conclusion, the cooling system is reliable. Cooling down the CPU, and GPU is extremely important. The way this device works is that the heat gathers up in the heat plates, the heat pipe transfers the warmth to the heatsink. As the brushless fan turns at an agile pace, the cool air that is created will then flow into the heatsink, pushing the heat out. We observed that the cooling system is an accomplishment, because it is a spectacular invention for history's devices like this laptop.

<b>Thermal Conductivities</b>		
<b>Substance</b>	<b>Thermal Conductivity, <math>k</math></b>	
	<b>kcal</b> <b>(s · m · C°)</b>	<b>J</b> <b>(s · m · C°)</b>
Silver	$10 \times 10^{-2}$	420
Copper	$9.2 \times 10^{-2}$	380
Aluminum	$5.0 \times 10^{-2}$	200
Steel	$1.1 \times 10^{-2}$	40
Ice	$5 \times 10^{-4}$	2
Glass	$2.0 \times 10^{-4}$	0.84
Brick	$2.0 \times 10^{-4}$	0.84
Concrete	$2.0 \times 10^{-4}$	0.84
Water	$1.4 \times 10^{-4}$	0.56
Human tissue	$0.5 \times 10^{-4}$	0.2
Wood	$0.3 \times 10^{-4}$	0.1
Fiberglass	$0.12 \times 10^{-4}$	0.048
Cork	$0.1 \times 10^{-4}$	0.042
Wool	$0.1 \times 10^{-4}$	0.040
Goose down	$0.06 \times 10^{-4}$	0.025
Polyurethane	$0.06 \times 10^{-4}$	0.024
Air	$0.055 \times 10^{-4}$	0.023

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### 3. CMOS BIOS button battery

The CMOS BIOS Button Battery is an important component on the motherboard. Made in Germany by Verta, it came with three volts. It is a Lithium-Alloy battery. Connected to it are two wires, one red and the other, black. While red wire represents positive, black is negative. On the other end of the wires, a white plug is attached to secure the battery to the motherboard.

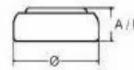


ML1220

Lithium-Alloy / Manganese Dioxide

#### Data Sheet <sup>1</sup>

Type Number	65013	
Type Designation	ML1220	
Designation IEC	---	
System	Lithium-Alloy / Manganese Dioxide	
Application	Organic Electrolyte	
UL Recognition	MBU / RTC	
	MH13654	
Nominal Voltage [V]	3.0	
Typical capacity C [mAh]	16 (Disch. 0.2 mA down to 2.0V at 20°C)	
Dimensions [mm]	min.	max.
	Diameter	12.3



In this analysis, we experimented on using a multimeter to estimate how much power is left. According to market standards two volts or lower are dead.



First, we set the multimeter to DC mode. Next, we attached the red probe to the positive side, and the black probe to the negative. Once the tip of the probe touched the battery, the answer appeared. The multimeter measured 0.38 volts. This meant that the battery was not usable.

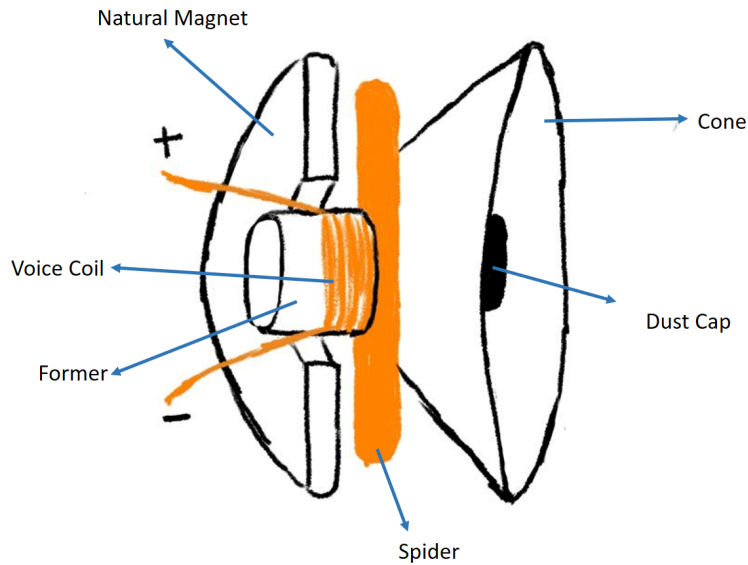


In our second attempt, the result was even lower. With an answer of 0.30 volts. Still this battery is not going to function.

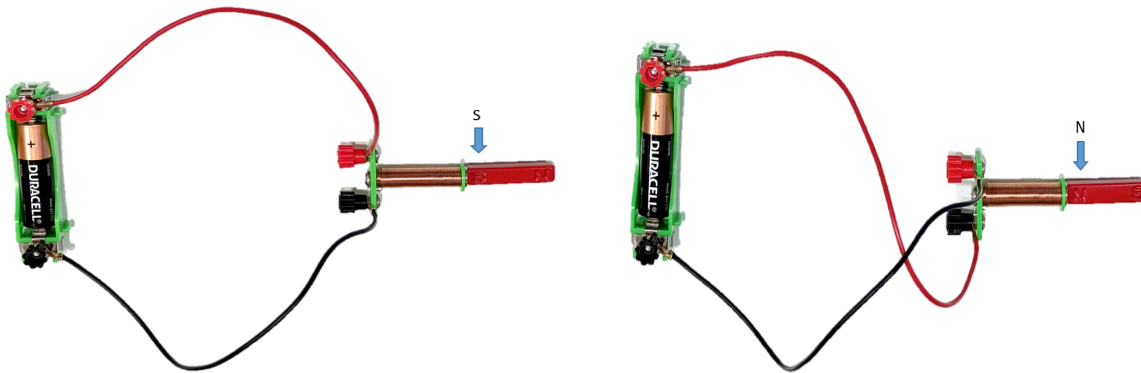


In conclusion, this battery will not be able to function. The device's time and date would be off. As a warning, beeping sounds could be heard. Also, an awful explosion may happen due to overheating. Yet this battery is an extraordinary element in the motherboard. It takes care of a handful of things. Without it, the laptop would be inconvenient. We would not be able to directly track the time or day.

# 4. Speaker



When positive and negative analog signals go through the wires, the voice coil attracts and repulses because it acts like an electromagnet. The voice coil's attraction/repulse moves the cone in and out. The movement of the cone rams in air molecules and is like a domino effect. This wave reaches the ear and your brain interprets it as sound. When the cone repulses it also does the same.



When Analog signals go in the copper wires, it creates magnetic pulses. It moves the natural magnet which is connected to the cone. The cone moves back and forth that creates sound waves.

How does a laptop play sound ? The user plays a music file from youtube/CD. Then, the laptop reads the digital data (binary file) and sends those data to the sound card. The sound card has a decoder and the decoder decodes those digital data and makes it into analog signals. Lastly, the analog signals will go through the wires to the speakers where it turns it is into sound waves.

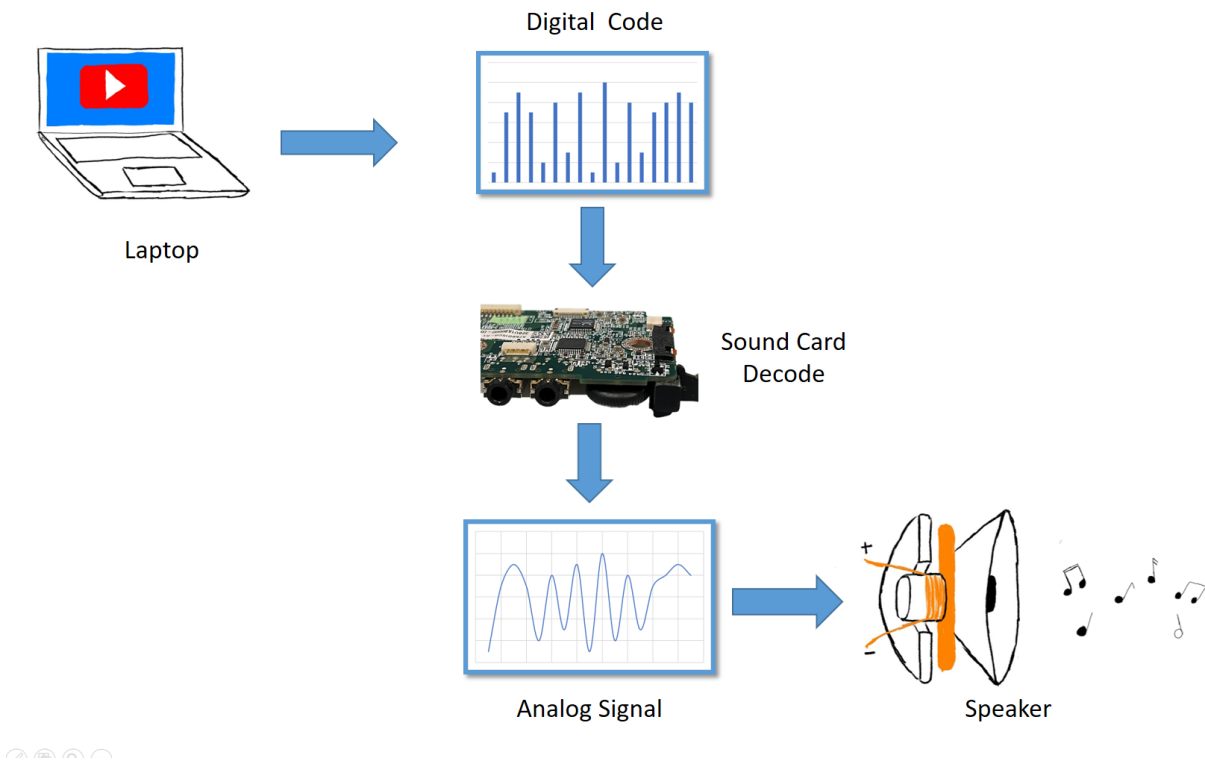
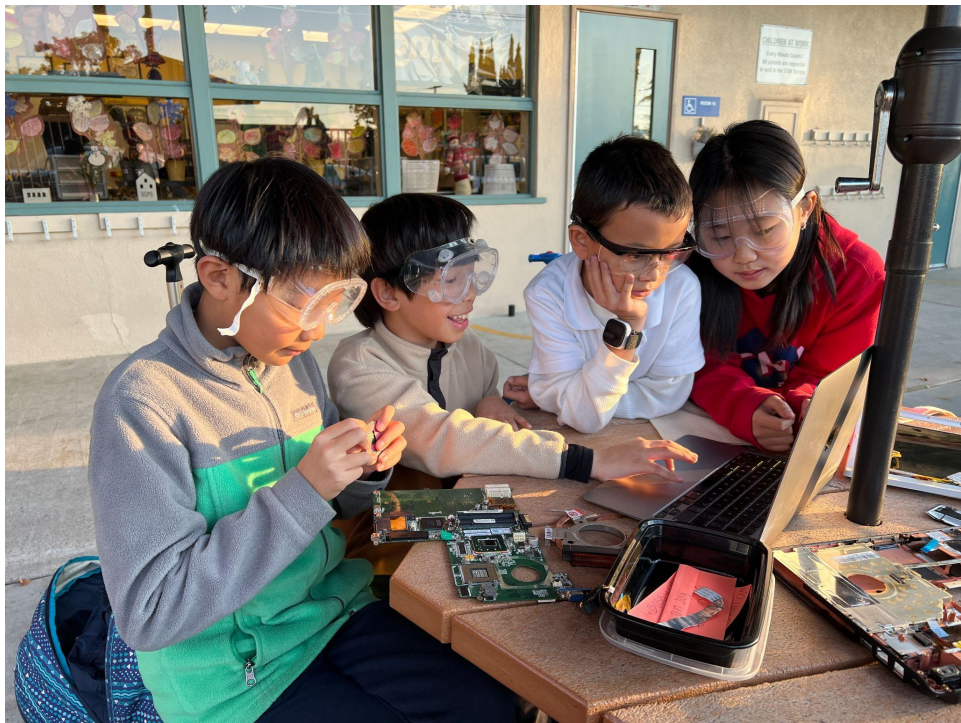


Diagram shows how to generate sound

### III. Conclusion

In conclusion, we learned more about how different components of a laptop operate. Also, we had an awesome time deconstructing and discussing this project. Exploring the inner-workings of this electronic device was unforgettable, and new things surprised us greatly. Through this experience, we learned the importance of teamwork and perseverance. While our knowledge of laptops grew, we truly understand that we have only scratched the surface of the iceberg. We just need to keep learning.



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