

A Window into the Past



2024 Online Challenge Submission Reverse Engineering Challenge - Middle School



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Section 1

Project Preparation

Project Introduction

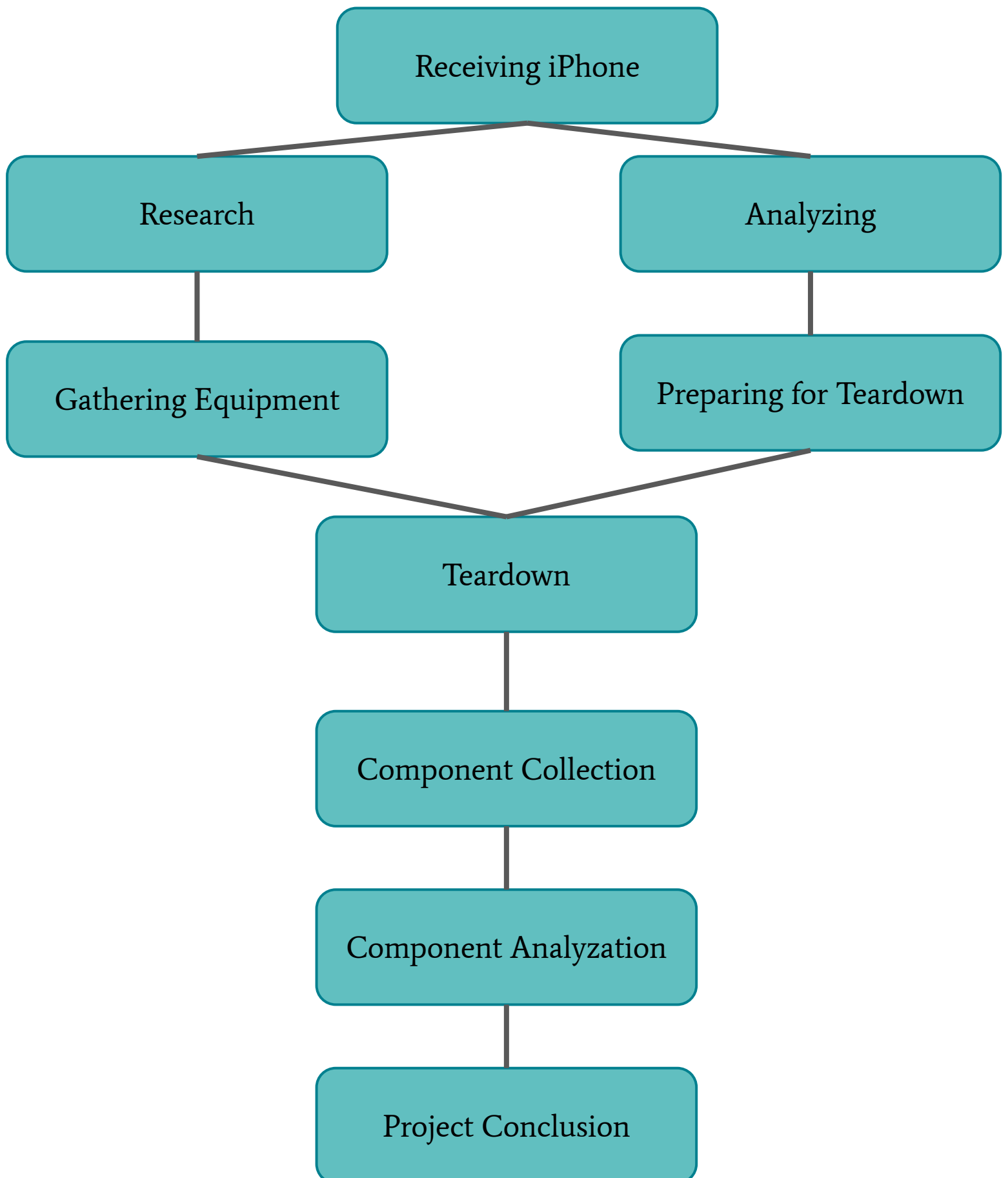
When approaching the idea of this project, we not only wanted to expand our engineering knowledge, but also use this as an opportunity to learn about an influential and important piece of technology. Thus, we thought: What better option than the very device almost everyone uses everyday which utilizes a melting pot of different engineering concepts?

Landing on the iPhone, we also desired to learn how the components and techniques used within it had changed over the years. In order to accomplish this, we chose to deconstruct an older model (the iPhone 4 - Verizon Version) which also possessed the merit of having a revolutionary processor, at the time, within the center of it. Finally, with the device acquired and the overall plan finished, we dove head first into the campaign.



Figure 1 - Front/Side View of iPhone 4

Project Process



Analysis - Part 1

As part of the analysis for the iPhone 4, research was conducted based on Apple's description of this device, The details deemed important were collected and compiled below.

Electronic Information Capacity

- 16GB
- 32GB
- 64GB

Size and Weight

- Height: 4.5 inches (115.2 mm)
- Width: 2.31 inches (58.6 mm)
- Depth: 0.37 inch (9.3 mm)
- Weight: 4.9 ounces (140 grams)

Display

- Retina display
- 3.5-inch (diagonal) widescreen Multi-Touch display
- 960-by-640-pixel resolution at 326 ppi
- 800:1 contrast ratio (typical)
- 500 cd/m² max brightness (typical)
- Fingerprint-resistant oleophobic coating on front and back
- Support for display of multiple languages and characters simultaneously

Camera, Photos, and Video

- 8-megapixel camera
- Autofocus
- Tap to focus
- Face detection in still images
- LED flash
- Video recording, HD (1080p) up to 30 frames per second with audio
- Video stabilization
- Front camera with VGA-quality photos and video at up to 30 frames per second
- Photo and video geotagging

Power and Battery

- Built-in rechargeable lithium-ion battery
- Charging via USB to computer system or power adapter
- Talk time: Up to 8 hours on 3G, up to 14 hours on 2G (GSM)
- Standby time: Up to 200 hours

Audio Playback

- Frequency response: 20Hz to 20,000 Hz
- MP3 VBR, Audible (formats 2, 3, 4, Audible Enhanced Audio, AAX, and AAX+), Apple Lossless, AIFF, and WAV

Sensors

- Three-axis gyro
- Accelerometer
- Proximity sensor
- Ambient light sensor

Other Notes

- Mercury-free LED-backlit display
- Arsenic-free display glass
- Brominated flame retardant-free
- PVC free
- Majority of packaging made from post-consumer recycled fiberboard and biobased materials
- Power adapter outperforms strictest global energy efficiency standards

Analysis - Part 2

This portion of the analysis consisted of finding direct schematics/diagrams of the iPhone 4 (Verizon Model) and its components in order to grasp a better understanding of them before the actual teardown begins.

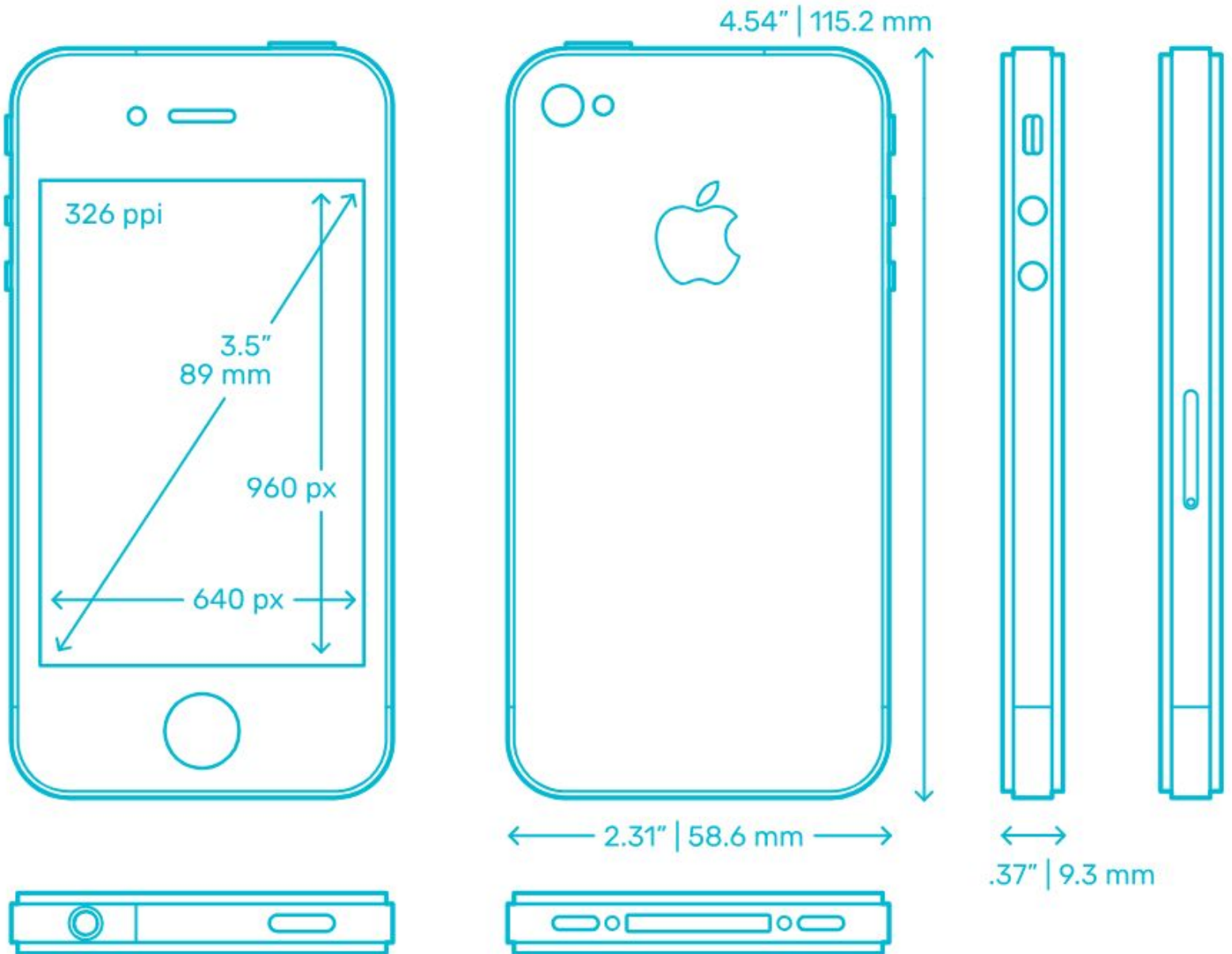


Figure 2 iPhone Schematics

Analysis - Part 2

This portion of the analysis consisted of finding direct schematics/diagrams of the iPhone 4 (Verizon Model) and its components in order to grasp a better understanding of them before the actual teardown begins.

iPhone 4 - Expanded Parts Diagram

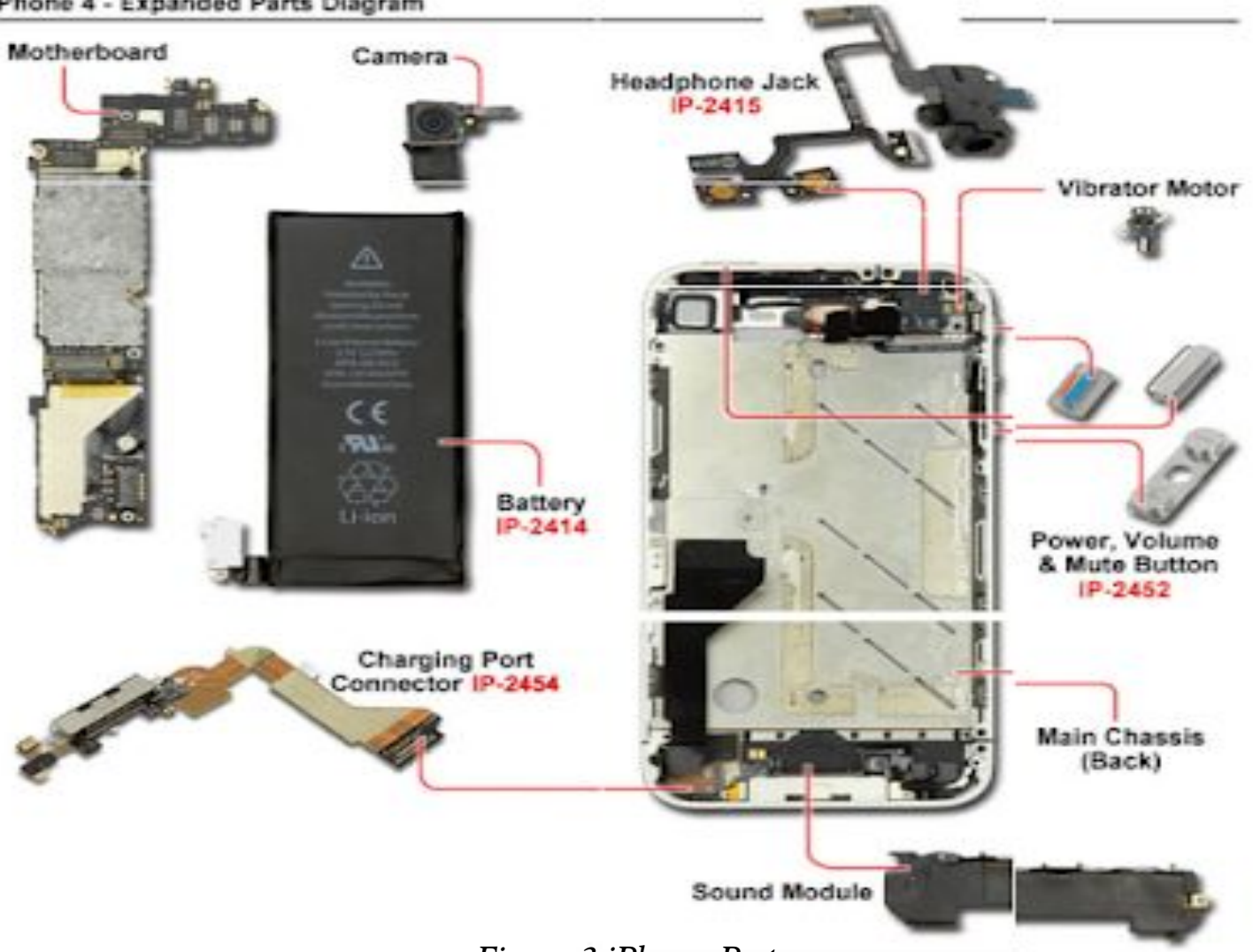


Figure 3 iPhone Parts

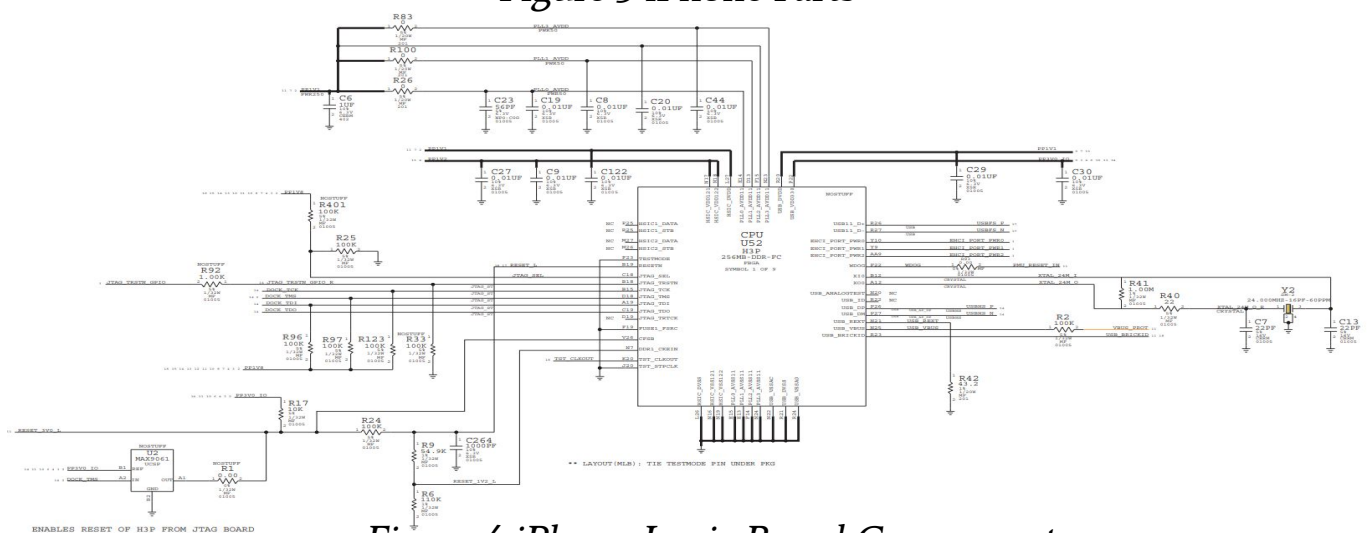


Figure 4 iPhone Logic Board Component

Planning - Part 1



The first part of planning that we underwent was gathering the proper tools for the teardown. The majority of the tools we found came from two repair kits from the company iFixit.

The tools included a *bit driver* with *three different attachments*, a *tweezer*, a *opening bar*, a *spudger tool*, and a *suction handle*.

Figure 5 - iFIXIT Repair Kit

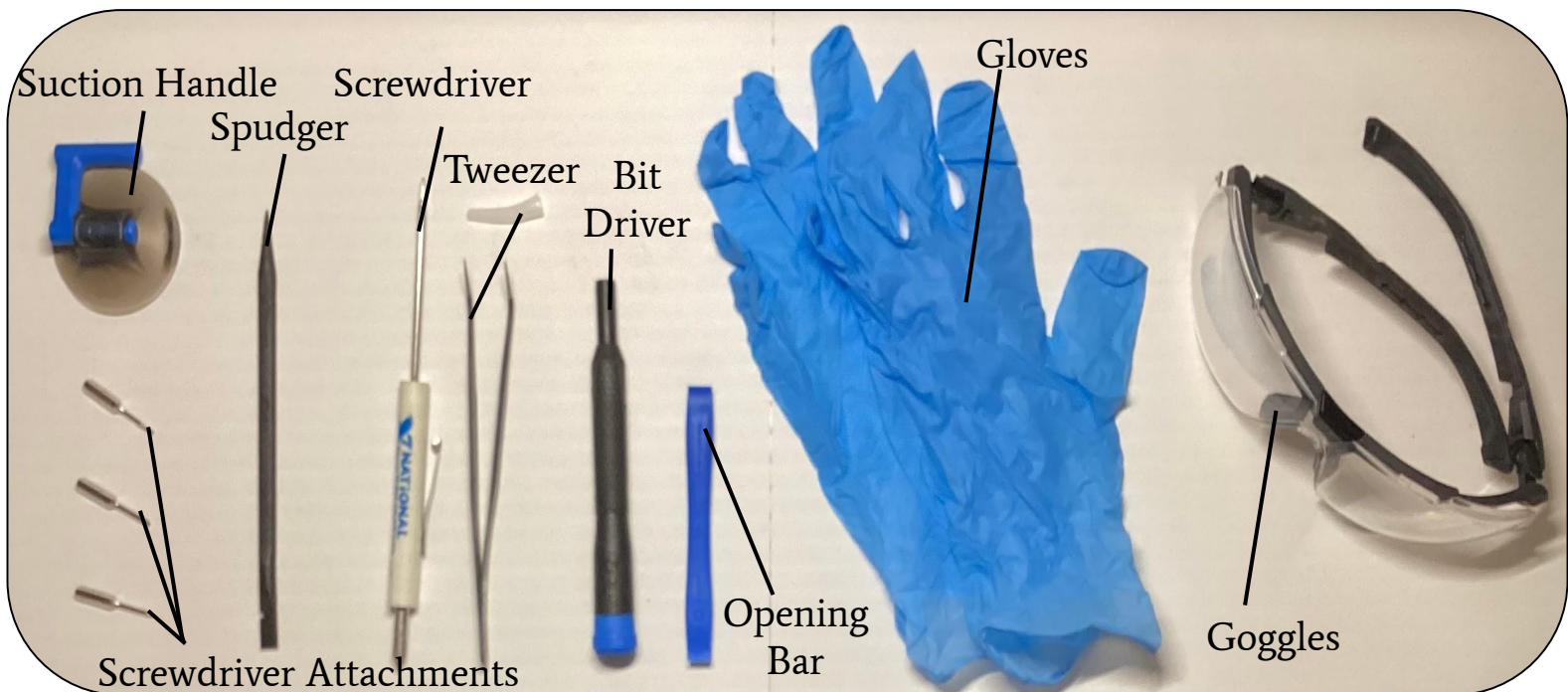


Figure 6 - Collected iPhone Teardown Tools

After assembling the tools into an organized collection, we also decided to add a *normal screwdriver* to the arsenal. Additionally, a *pair of gloves* and *goggles* were also gathered in order to maintain proper protection during the teardown process.

Planning - Part 2



The second part of planning came from researching the best way to disassemble the iPhone in a safe, organized manner. This research was conducted using the iFixit Teardown Guide, which explained when and how to remove parts for the majority of the phone.

The rest of the deconstruction process was planned by viewing the schematics of the device and using methods from iFixit.

Figure 7 - iFixit Teardown Guide

Stage 1



Figure 8 - iPhone 4

Stage 2



Stage 3



Stage 4



Figure 9, 10, 11 - Inner Electronics

After collecting the needed information, the teadown was concluded into a 4-stage process. The first stage is splitting the iPhone into its two separate parts. The second stage is removing the middle electronics, the third stage is removing the bottom electronics, and the fourth stage is removing the top electronics.



Section 2

Device Teardown



Teardown - Stage 1

Goals

- Remove device's panel's supporting screws
- Loosen device's panels using the suction handle
- Separate two portions of device using the suction handle

Notes

- Please use correct tools and protective equipment to avoid harm
- Be careful when removing back panel to reduce the chances of shattered glass

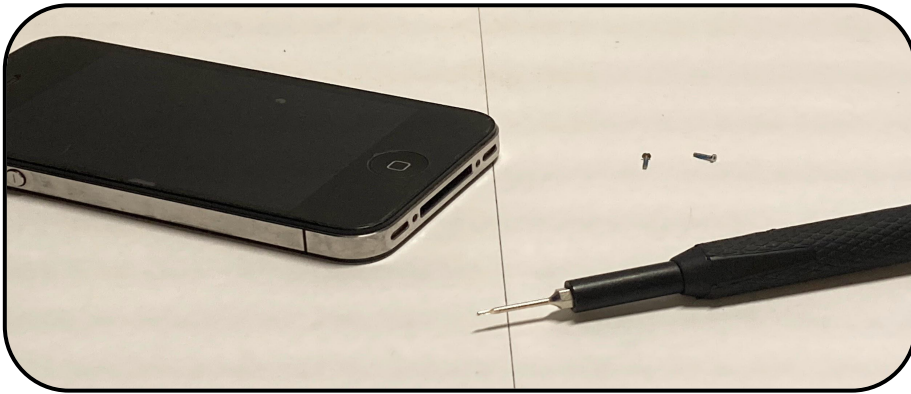


Figure 12 - iPhone Supporting Screws Being Removed

Step 1 - Remove supporting screws for the device's two panels

Goals ✓

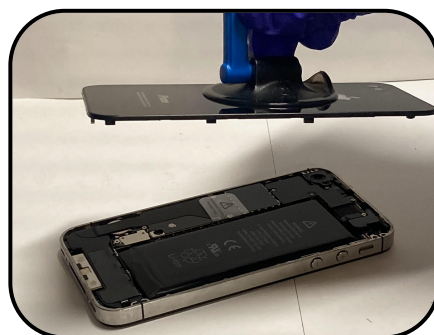


Figure 13, 14 - iPhone Panel Being Removed

Step 2 - Create a hold on the back panel using the suction handle. Then, remove the back panel

Goals ✓ ✓



Figure 15 - Separate iPhone Halves

Step 3 - Simply remove the suction handle and separate the two halves of the device.

Goals ✓ ✓ ✓

Teardown - Stage 2

Goals

- Remove device's battery
- Remove device motherboard and sever connections
- Remove middle electronic metal shields

Notes

- Please use correct tools and protective equipment to avoid harm
- Be careful not to damage the battery as to not release dangerous chemicals



Figure 16, 17 - iPhone Battery Being Removed

Step 4 - Use the provided pull tab to remove the battery

Goals

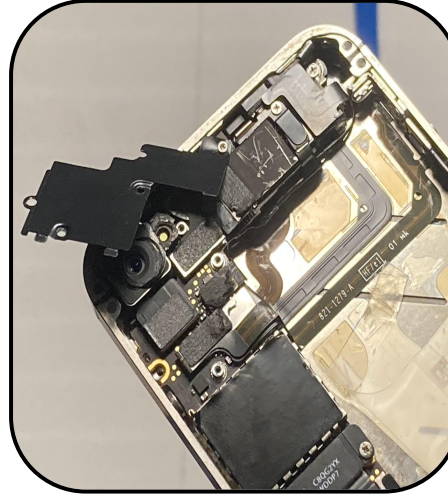
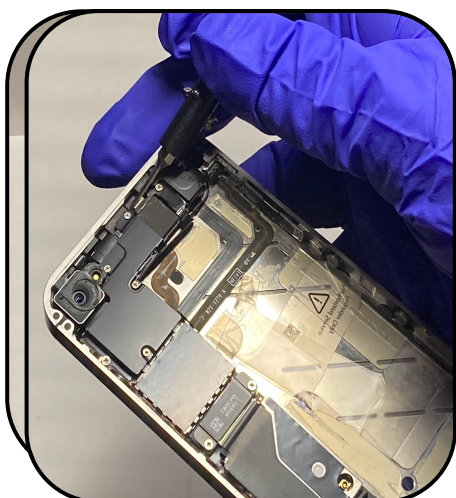


Figure 18, 19 - iPhone Panel Being Removed

Step 5 - Remove electronics shield on the upper portion of the motherboard

Goals



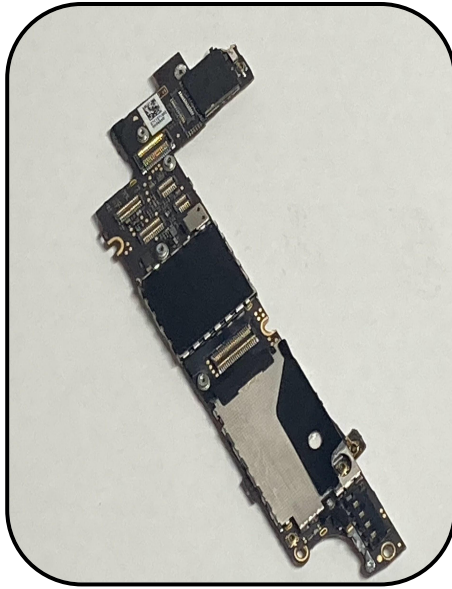
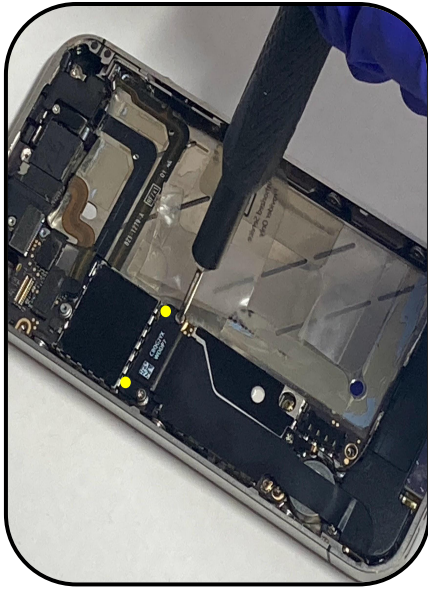
Teardown - Stage 2

Goals

- Remove device's battery
- Remove device motherboard and sever connections
- Remove middle electronic metal shields

Notes

- Please use correct tools and protective equipment to avoid harm
- Be careful not to damage the battery as to not release dangerous chemicals

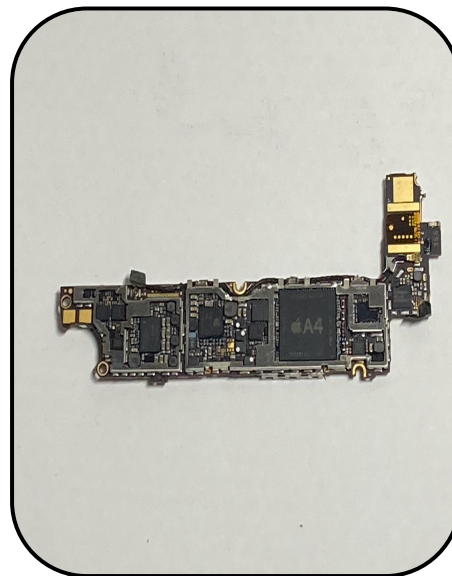
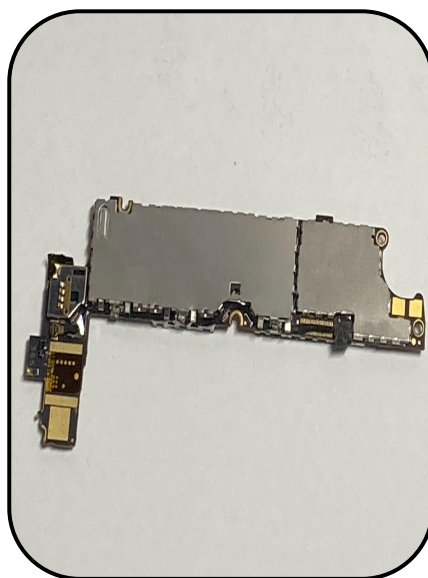


Step 6 - Remove the screws holding the motherboard in place and loosen it using the opening bar. Then, remove it from the device.

Goals

- ✓
- ✓
-

Figure 20, 21 - Motherboard Being Removed



Step 7 - Take the separated motherboard and use the opening bar and screwdriver to remove the metal shields. Next, remove the rubber covers below the metal shields.

Goals

- ✓
- ✓
- ✓

Figure 22, 23 - iPhone Panel Being Removed

Teardown - Stage 3

- Remove bottom electronics
- Sever bottom electronics connections

Goals

Notes

- Please use correct tools and protective equipment to avoid harm
- As you get closer to the actual screen, make sure to use light pressure as to not break or shatter the glass

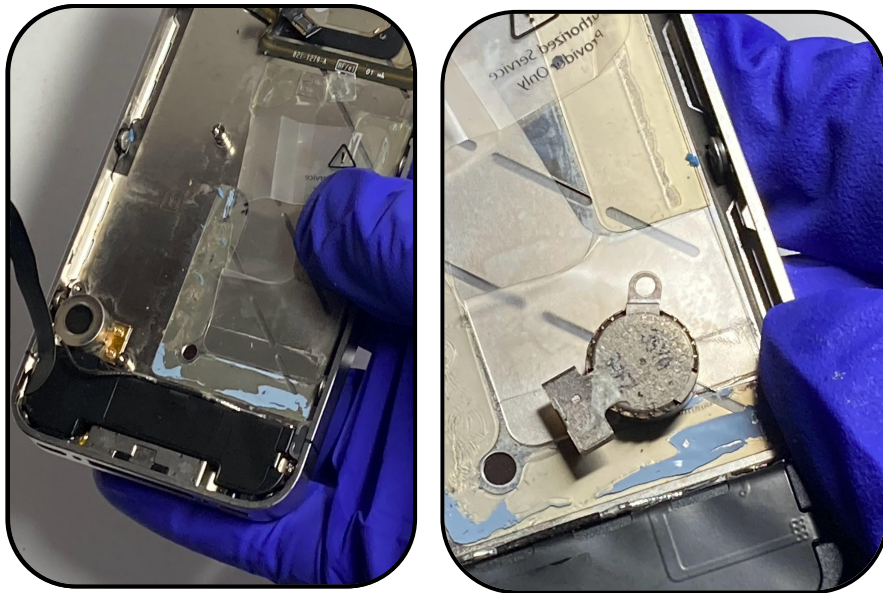


Figure 24, 25 - Vibration Creator Being Removed

Step 8 - Remove the screws holding the vibration creator in place and scrape away the glue beneath it using the screwdriver. Then, use the opening bar to remove it.

Goals

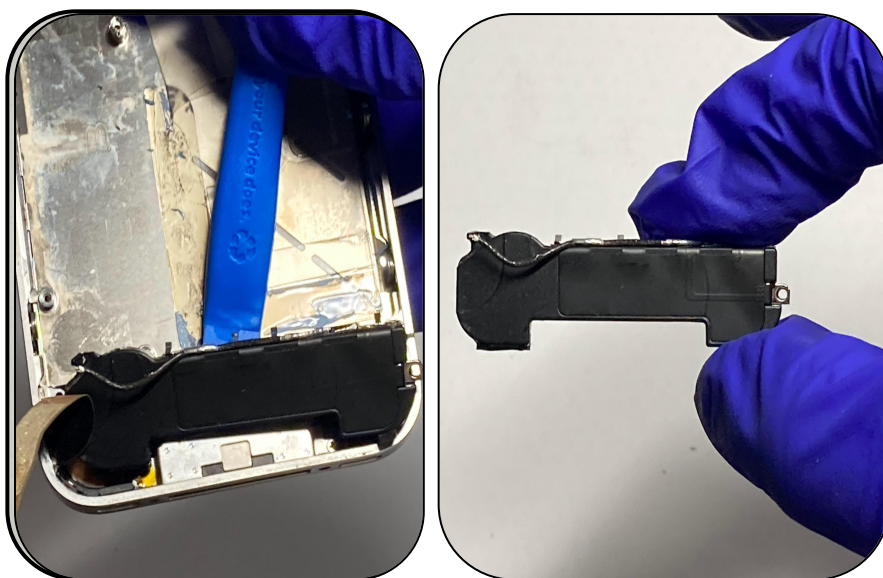


Figure 26, 27 - Speaker Being Removed

Step 9 - Use the opening bar to pry off the speaker and bring it out of the device.

Goals

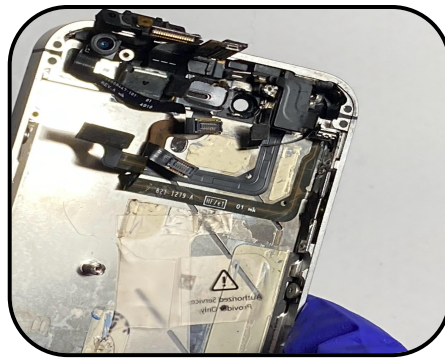
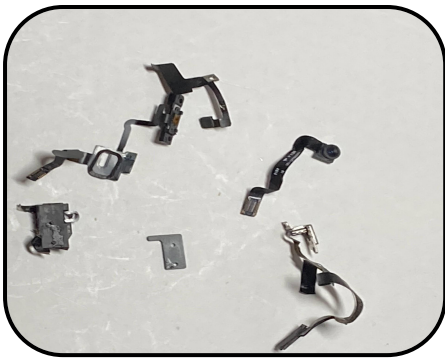
Teardown - Stage 4

Goals

- Sever upper electronics connections
- Remove upper electronics
- Remove any leftover parts

Notes

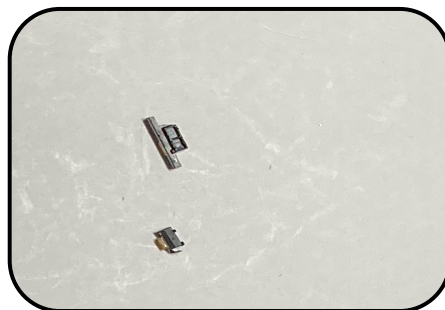
- Please use correct tools and protective equipment to avoid harm
- Be careful when removing leftover parts, and verify they are in fact parts instead of the actual device casing



Step 10 - Remove connecting wires and any loose accessories with them

Goals

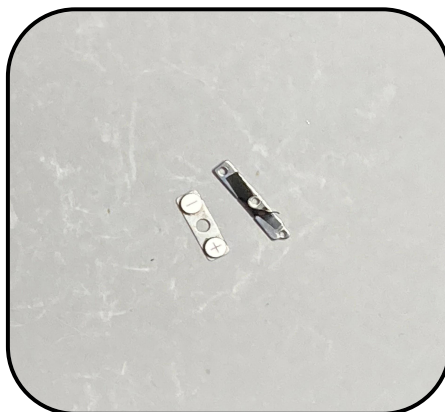
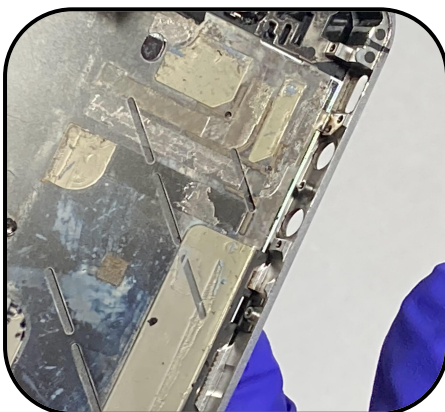
Figure 28, 29 - iPhone Wires Being Removed



Step 11 - Use the screwdriver to remove loose structure pieces

Goals

Figure 30, 31 - Structure Blocks Being Removed



Step 12 - Use the opening bar to remove the volume buttons and control

Goals

Figure 32, 33 - Removed Volume Control Elements

End of Teardown



Section 3

Component Analysis



Component Analysis - Outer Shell

This section of Component Analysis will consist of the parts that hold the inside electronics and are exposed to the outside world.

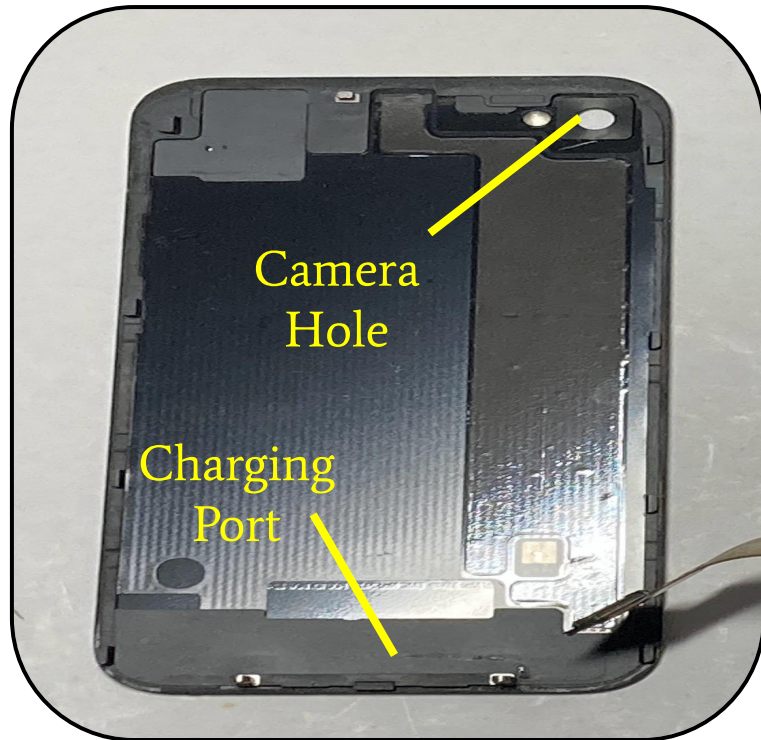


Figure 34 - iPhone Internals

This panel makes up the rear portion of the outer shell. This part includes an metal casing covered with glass. There is also two holes within the casing, one for a back camera and one for a charging port.

This panel makes up the front portion of the outer shell. This part includes a metal casing covered by glass, with a screen between the layers. This casing has several holes, two near the top for a camera hole and an on/off switch. There are holes near the middle for a sound toggle and volume buttons as well as a charging port near the bottom.

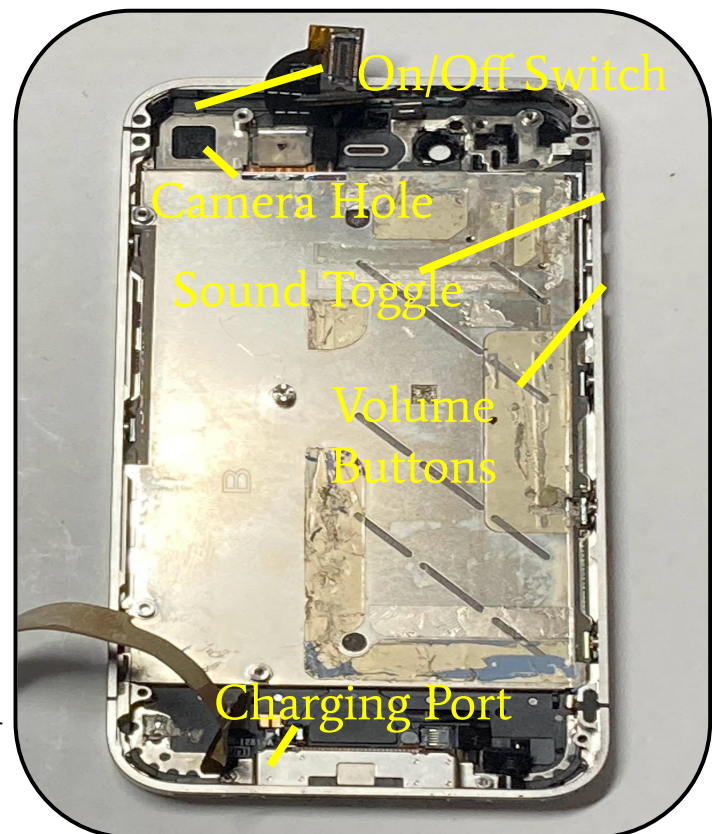


Figure 35 - iPhone Internals 18

Component Analysis - *Input Electronics*

This section of Component Analysis will consist of the parts that take input in from the outside world.







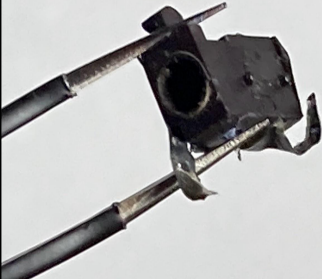



Part	Description	Location
	<p>Volume Control - a set of two buttons and their electrical innards used to control the device's volume.</p>	
	<p>Volume Toggle - metal switch used to toggle on and off sound for the device.</p>	
	<p>Rear Camera - large camera and its connecting wires. Mounted on the back of the device.</p>	
	<p>Headphone Jack - electrical piece with port for headphones. Uses wires to connect to the rest of the device's system.</p>	
	<p>Front Camera - a small camera and its connecting wires. Mounted on the front of the device.</p>	

Figure 36 - 45 - iPhone Internals

Component Analysis - *Inner Electronics*

This section of Component Analysis will consist of the parts that make up the major electronic elements of the device.

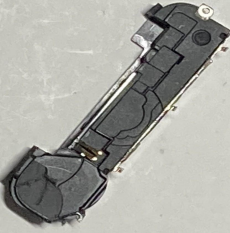









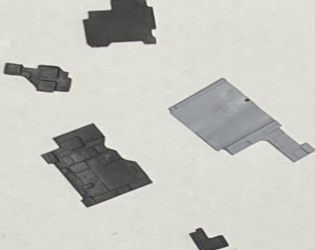



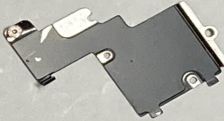



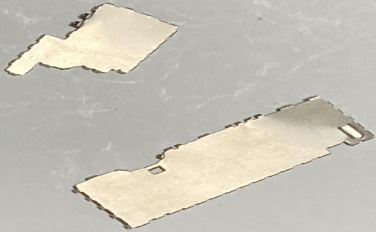

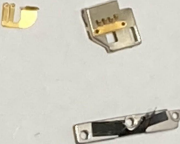

Part	Description	Location
	<p>Speaker- small and long metal electronic device used to produce sound for the device.</p>	
	<p>Vibration Creator - small electronic used to produce vibrations for the device.</p>	
	<p>Battery - plastic brick filled with chemicals used to hold an electrical charge for the device.</p>	
	<p>Earpiece - a small electronic mounted at the top of the device used to pick up outside sound.</p>	
	<p>Charging Port - a large port used to plug in the device and charge its battery.</p>	

Figure 46 - 55 - iPhone Internals

Component Analysis - Structure Pieces

This section of Component Analysis will consist of the parts that are not electronic but still contribute to the structure of the device.

Part	Description	Location
	<p>Rubber Padding - padding used to absorb shock and prevent damage to components</p>	
	<p>Assorted Wires - wires used to make connections between electrical components</p>	
	<p>Metal Shields - shields used to protect electronics from blunt damage</p>	
	<p>Assorted Structure Pieces - plastic and part metal non-electronic parts used to hold others in place</p>	
	<p>Heat Shields - shields used to dissipate heat and regulate temperature of components</p>	
	<p>Assorted Connectors - non-electronic pieces used to connect other parts together</p>	

Component Analysis - Structure Pieces

This section of Component Analysis will consist of the parts that are not electronic but still contribute to the structure of the device.











Part	Description	Location
	<p>Short Screw - short metal screw covered in loctite to increase friction. Used to secure components.</p>	
	<p>Medium Screw - medium metal screw covered in loctite to increase friction. Used to secure components.</p>	
	<p>Long Screw - long metal screw covered in loctite to increase friction. Used to secure components.</p>	
	<p>Spacer - thin metal spacer used to reduce friction and create spacing between components</p>	
	<p>Flat Head Screw - a small screw paired with a large flat head.</p>	

Figure 67 - 76 - iPhone Internals

Component Analysis - Logic Board (front)

This section of Component Analysis will consist of the motherboard and the controlling electrical components.



Part and Description	
Apple A4 Processor	a system-on-system chip (SoC) that combines a low-power CPU, a graphics processing unit (GPU), and other hardware. It finds an ideal balance between battery life and speed.
Qualcomm PM8028 Power Management	isolated base module designed for power switching applications operating at frequencies to 20kHz. Control circuits provide optimum gate drive and protection for the IGBT and free-wheel diode power devices.
Dialog D1815A Power Management IC (Apple branded 338S087)	provides active power loss protection, hot swap capability, and autonomous storage capacitor health monitoring.
343S0499 - Texas Instruments Touchscreen Controller	Small chip responsible for sensing pressure and controlling devices' touchscreen
SKY77711-4 - Skyworks Power Amplifier Module for CDMA/PCS	fully matched 10-pad surface mount module developed for Wideband Code Division Multiple Access (WCDMA) applications.
SKY77710-4 - Skyworks Power Amplifier Module for dual-mode CDMA/AMPS	hybrid, multimode multiband (MMMB) Power Amplifier Module (PAM) that supports 2.5G and 3G/4G handsets and operates efficiently in GSM, EGPRS, EDGE, WCDMA, and LTE modes.

Figure 77 Logic Board Front

Component Analysis - Logic Board (back)

This section of Component Analysis will consist of the motherboard and the controlling electrical components.



Part and Description

Qualcomm MDM6600

32-bit ARM system-on-chip with 3G wireless capabilities developed by Qualcomm and introduced in 2003 for the mobile market. Part of the MSM6xxx Enhanced Multimedia Platform offering support for the most advanced features such as security, position-location, camera & imaging, audio, video, streaming, and conferencing.

Toshiba TH58NVG7D2FLA89 16 GB NAND Flash

16GB flash chip that uses eight of Toshiba's 2B NAND chip

Toshiba Y890A111222KA

DRAM + flash MCP

RS KMOD16104

electrical component that provides Wi-Fi/Bluetooth connections

Figure 78 Logic Board Back



Section 4

Concluding Thoughts



Summary Report

From this project, we learned several things. We learned how to deconstruct devices in an organized manner, do research on different components of devices, and compile data into a concise yet informative manner. While participating in the teardown, we were also able to observe many engineering techniques as well as learn more about them during the mentioned research phase. Most importantly, this project taught us how to work together as a team and showed us what determination looks like and what it can help us accomplish.

To conclude, this project helped us gain new skills, and allowed us to dive deeper into technology from the past. Thanks to this project, we have been able to gain new knowledge, and prepare ourselves better for careers in STEM.

Citations

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