Unit Testing

1. The current/voltage of the coils (electrical)
    - How: We will use a multimeter to measure the current/voltage of the coils when a phone is placed on the wireless charger. This will help determine the range of values our scanner should look for when finding the optimal location for the charger as well as patterns of behavior that may be useful.
    - Tools: Multimeter
2. Two-axis rail system mobility tests
    - How: We will manually set a position for the coils to move to in our software. Repeating this with different locations will allow us to try different positions and test the physical capabilities of the rail system.
    - Tools: Microcontroller, Rails, Motors
    - Subtest: The microcontroller's functionality with our motors
        - How: We will test to see if the microcontroller can read the data given by the sensors, and convert that data into instructions for the motors. We will test a few different motors in order to determine connectivity and efficiency between the motors and microcontroller.
        - Tools: The microcontroller, motors, sensors and our software
3. The microcontroller's functionality with our sensors (hardware and software)
    - How: We will test to see if the sensors can successfully send data to the microcontroller in a readable format. We plan to test with a few microcontrollers, microcontroller software, and sensors in order to ensure compatibility and efficiency between the two devices as well as respond to IR data.
    - Tools: Microcontrollers, sensors

4. Thermal conductivity of various surfaces
    - How: We will perform experiments on various materials to determine which material has ideal thermal conductivity. Material strength will also be considered.
    - Tools: Wireless charger shell, phone, coils

Interface Testing

Interface 1: the motors will interface with the microcontroller unit to move the charger to the optimal position.

- Testing: we will program the motors via the microcontroller unit, and through trial and error, we will figure out how fast these motors move and in which direction. From there, we can use the information from the current sensor to determine where to move it to.

Interface 2: the infrared sensor will interface with the microcontroller unit to detect if a phone is on the charger.

- Testing: we will configure the infrared sensor to determine when a phone is placed on the charger.

Interface 3: the voltmeter/current sensor will interface with the microcontroller unit to determine the maximum current flow between the charging coil and the phone.

- Testing: we can make a graph of (distance between the phone and the current sensor) vs (current flow to the phone). We can find the maximum of this graph to optimize the charging power to the phone.

Integration Testing

Connectivity between the microcontroller and motors, and connectivity between the microcontroller and sensors are the two most critical integration paths in our design. If the microcontroller and the motors are improperly implemented, then the charger will be unable to move to the phone in order to charge it. If the microcontroller and the sensors are improperly implemented, then the charger will be unable to even locate the phone in the first place. These two integration paths will be thoroughly tested via Unit Tests 2 and 3, discussed in section 5.1 of this document.

System Testing

Our project will be comprised of four main components that will need to be individually tested before we can put them together
and test the integration between them:

- Circuit Design
- Software Design
- Mechanical Design
- Physical Design

Knowing all of our individual strengths we plan on splitting the testing up in groups such that the designers are the lead testers.

Circuit Designers

We have a couple of electrical engineering peers that will lead the testing for the internal circuitry of the wireless charger. We will need to design the hardware to be able to communicate with the arduino circuit board and output a current reading. The components that we will need to use are a current sensor to give us a desired output.

Software Designers

The leading software design team will be tasked with linking the hardware output in the arduino with the hardware that will move the coil. To do this, we will need some team members that specialize in software development and computer engineering. The main goal of our testing in terms of the software is to capture the data input from the arduino and convert that to move the interior coil. We will be looking for the software designers to be able to optimize the coil permission.

Mechanical Designers

For the mechanical design we will need to ensure that the coil will be able to move freely and with the least amount of power necessary. This will be one of the main factors that will keep our design from overheating. To do this testing we will need to make sure that our design is able to reach the edges of the charger in case the user orients their device in such a way.

Physical Designers

For those creating the physical design, they will need to test many different designs in order to maintain a slim, aesthetic look, but fit all of the necessary components. To do this, it will be the entire team’s responsibility to try to minimize the space taken by each component. We will also need to create a physical design such that the phone is able to charge with the same speed as competitors' charger designs.

Regression Testing

The old functionality was simply a wireless charger that the user had to properly orient, so our new additions only come with a moving, self-aligning charger.

We have been trying to set up our testing plan in such a way that it will ensure the components inter-functionality. We will test our hardware so that we know we are getting an accurate reading from the coil. We will have to make sure there is a clear maximum. This will be one of the critical features that will be vital for our project's success. To ensure that this will not break we will need to use a specific orientation of resistors to avoid overheating.

Another one of the critical features would be the mechanism that aligns the interior coil. We will need to make sure our device has the capability to power the two stationary motors. This could potentially allow us to later allocate the power to the charging coil. This will need to be tested, but it could potentially solve the issue of having a thick case. In order to prevent this mechanical component from breaking we will need to include buttons or switches at the limits of our scanning surface to ensure the motors know then to stop.

Acceptance Testing

We will take the data we collected from the acceptance testing below, present it to our client, and inquire about any additional concerns/testing ideas he might have.

- We will test that the device can detect a multitude of different cell phones
- We will measure the device to prove it fits within physical size constraints
- We will place and replace a phone and measure the noise produced by the motors to ensure it is acceptable
- We will measure the noise output of the electronics to ensure no discomfort is caused by electronics “whining”
- We will write code to move the charging unit around continuously to ensure robustness
- We will charge multiple phones from 0% to 100% and compare it to a standard wireless charger
- We will measure the temperature of the device after consistent charging to ensure a safe temperature is maintained

Results

While not all tests have been performed as of yet, our group has performed some preliminary testing before prototype construction, specifically the coil's voltage and current behavior. Unfortunately, our experiment's results were found to be flawed. Our semi regular client meetings proved to be useful however because if this error was not found early on, our group might have utilized flawed data for further design work such as microcontroller programming. Image 1 shows the data collected.

Distance from center (mm)	Coil resistance (ohms)	Coil voltage (mV)	Coil current (mA)
0	2.5	110	44
1	2.5	80	32
2	2.5	70	28
3	2.5	65	26
4	2.5	52	20.8
5	2.5	30	12
6	2.5	22	8.8
7	2.5	6	2.4
8	2.5	9	3.6
9	2.5	9	3.6
10	2.5	9	3.6

Distance from center (mm)	Coil resistance (ohms)	Coil voltage (mV)	Coil current (mA)
0	2.5		
1	2.5		
2	2.5		
3	2.5		
4	2.5		
5	2.5		
6	2.5		
7	2.5		
8	2.5		
9	2.5		
10	2.5		

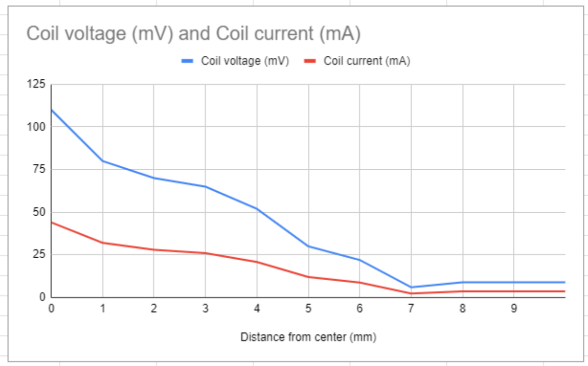

Image 1.

The cause of error was specifically the multimeter being incorrectly set to DC rather than AC current and voltage. While this does not prove that our design conforms to any useful specification, this does let us know that this specific design does not. We also realized that reading current from the charging coil introduces problems, as the multimeter's resistance is added to the circuit, inherently changing the behavior of the coil.