Board Buddy Design Document

University of Illinois Urbana-Champaign

ECE445 - Spring 2025

Team 34

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1. Introduction

1.1 Problem

Teachers too often waste precious class time erasing chalkboards and whiteboards. As any teacher or student can attest, this hiatus in class time hinders the ability to stay engaged and on track. Throughout the team's schooling experience, we have witnessed many teachers and students lose their train of thought during an erasing hiatus. There is a need for an erasing device that can work in parallel with the class, ensuring no moment is wasted in any learning environment.

While researching this project in particular, the team gained valuable insight that solidified our desire to solve this problem. The team had learned that in the Electrical and Computer Engineering Building, and the entire campus, custodians spend hours throughout the night erasing the boards for classes the following day. This not only wastes the time of custodians who have much more important tasks to undertake but also wastes the money of the university as it pays to have someone erase a board.

1.2 Solution

The team has proposed a multi-fold device solution to these problems. Dubbed the Board Buddy, the device will act as an automatic erasing apparatus attachable to any whiteboard or chalkboard in the Electrical and Computer Engineering Building. As the mounting uses a magnetic solution, this erasing device can also be implemented on most educational boards currently made.

The Board Buddy will be integrated into a user-friendly application that will allow the device to operate wirelessly. This application will allow remote activation so that the user will only need to be near the room to erase the board. This will save the custodians hours of nightly work. The device will also allow for immediate activation upon user input so that teachers can seamlessly transition from topic to topic on a busy board. This device will go even further to allow for timed board erasing. Being set to erase the board at a certain time, teachers can integrate this device into their schedule so that they enter a classroom with a clean board even if they have a midday class.

1.3 Visual Aid

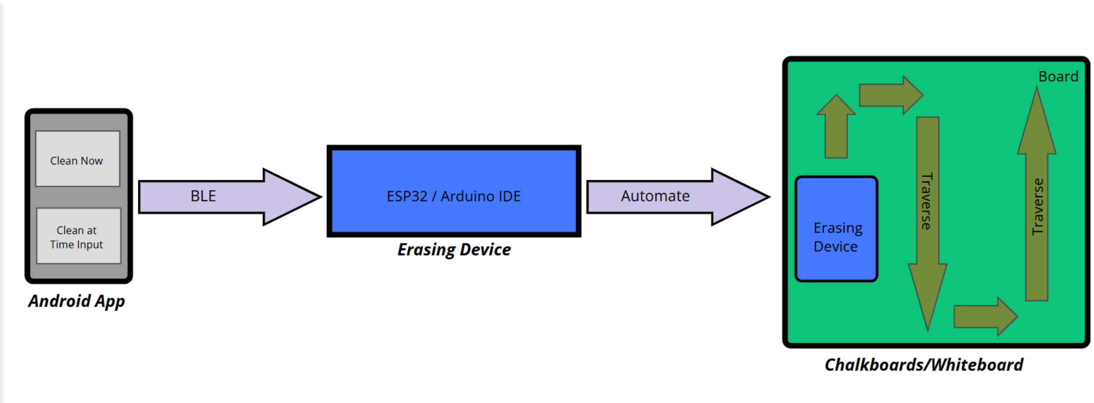

Figure 1

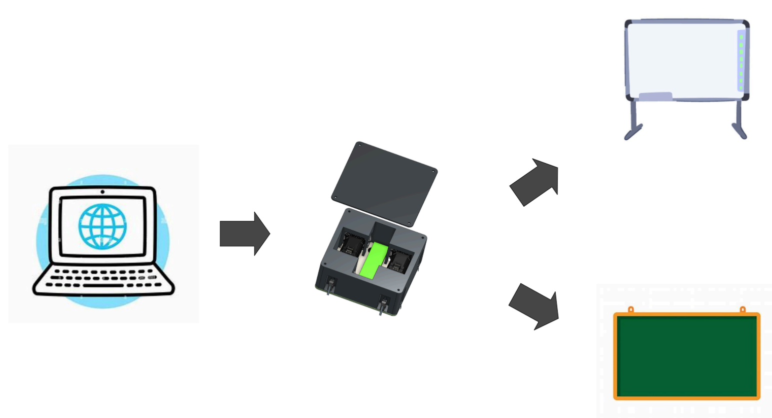

Figure 2

The above figures, (Figure 1 / Figure 2), displays the general usage of the device. Using a Android App, a user can connect the the device via BLE. On this app, one can automate the erasing of any educational board in the ECEB, as well as most educational boards currently made. The device will erase in an 'S' motion as it traverses omnidirectionally across the board. Intricate limit switch signal processing allows for the device to know when it is finished erasing while user friendly app abilities allow the user to erase the board at any time.

Figure 3

Figure 4

Figure 5

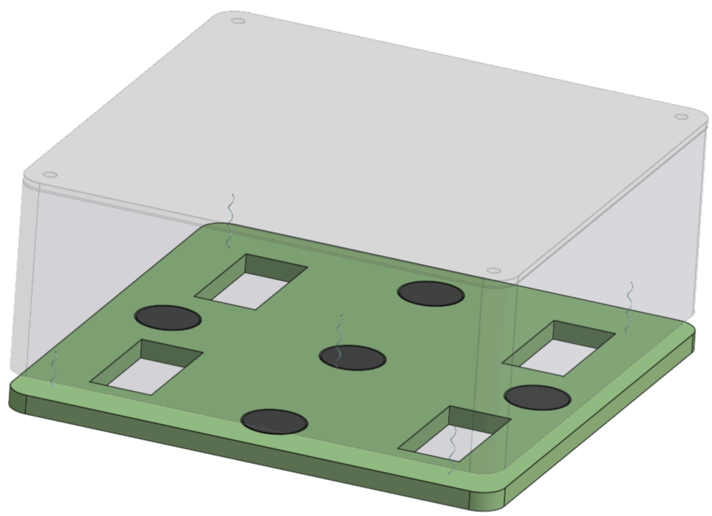

Figure 6

The above figures, (Figure 3 - Figure 6), displays the mechanical design of this device. Currently the design is 8in x 8in x 3in according to initial motor, wheel, and PCB sizing considerations. The design is currently using this 8in x 8in x 3in body to house the wiring and intricate electronics while a grouping of 8 limit switches are housed along the edges of the body (for edge detection). An 8in x 8in x 5mm magnetic base is spring loaded to this body and wrapped in an 'felt-like' material. This base extends to magnetically mount the device to the board as it traverses along its path. It is important to note that this model can be scaled further to account for changes in proposed sizes of electronics. Furthermore, it is important to note the significance of the contribution of the machine shop in this mechanical designing. The machine shop will be working with the team to cut appropriate sized holes in the ordered body to house the materials.

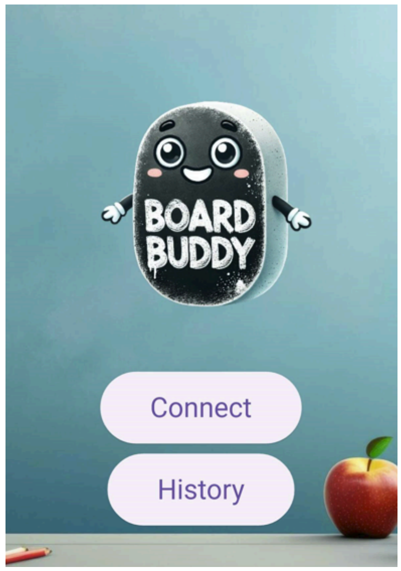

Figure 7

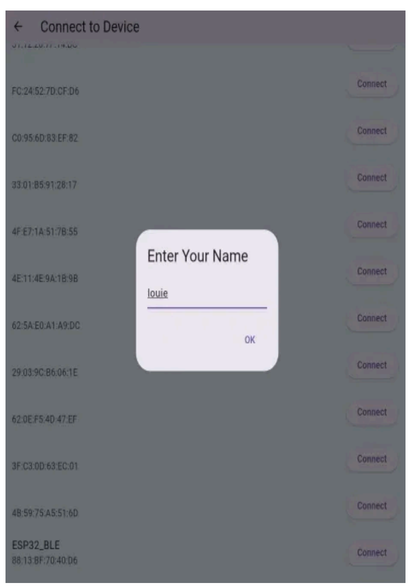

Figure 8

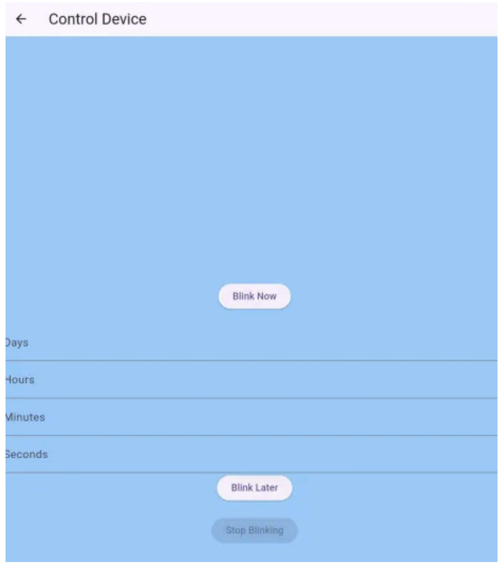

Figure 9

Figure 10

The above figures, (Figures 7-10), display the various screens within our Board Buddy Android Application. Made using Flutter interfacing with Arduino programming, this application can be run on any Android device to remotely control the Board Buddy. Upon opening, this application allows the user to either see the usage history or connect to the device right away. Choosing to connect to the device, the user will be met with a selection of BLE devices in which one must find the Board Buddy. Connecting to the device, the user will input a name to be logged in the history. Once on this control page, the user can choose to either erase the board now or set a time input to erase the board later.

1.4 High-level Requirements List

There are various things that our project must do to operate as planned, but there are three quantitative characteristics in particular that it must exhibit to solve the mentioned problems. These characteristics can be referenced in the bulleted list below:

High-Level Requirements	
1	The first quantitative characteristic is that this device must erase the majority of the residue in a single pass.
2	The next quantitative characteristic is that it must pass through a typical ECEB educational board (4’ x 8’) in under two minutes.
3	The final quantitative characteristic is that it must have app integration that will allow for remote and timed activation.

Table 1

2. <u>Design</u>

2.1 Block Diagrams

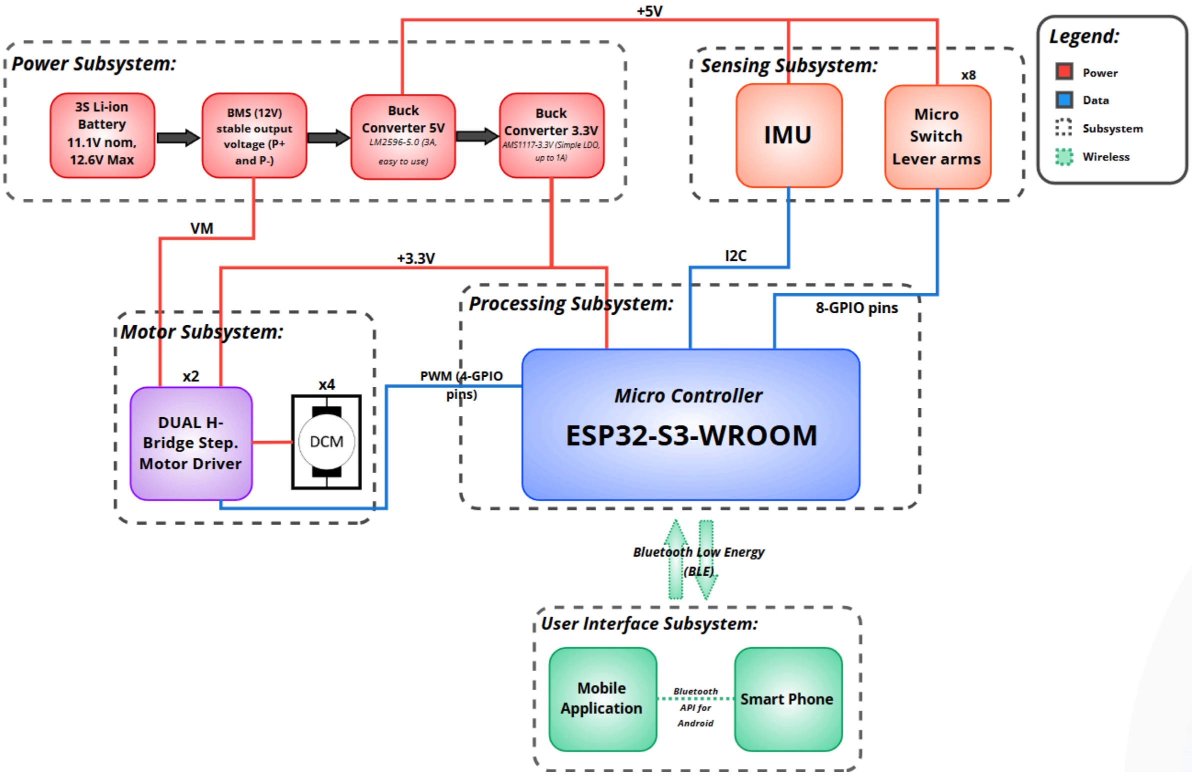

Figure 11

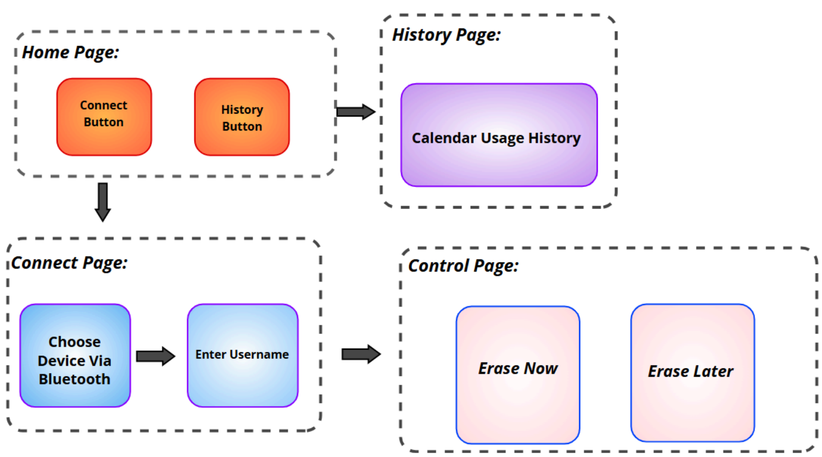

Figure 12

2.2 Subsystem Overview

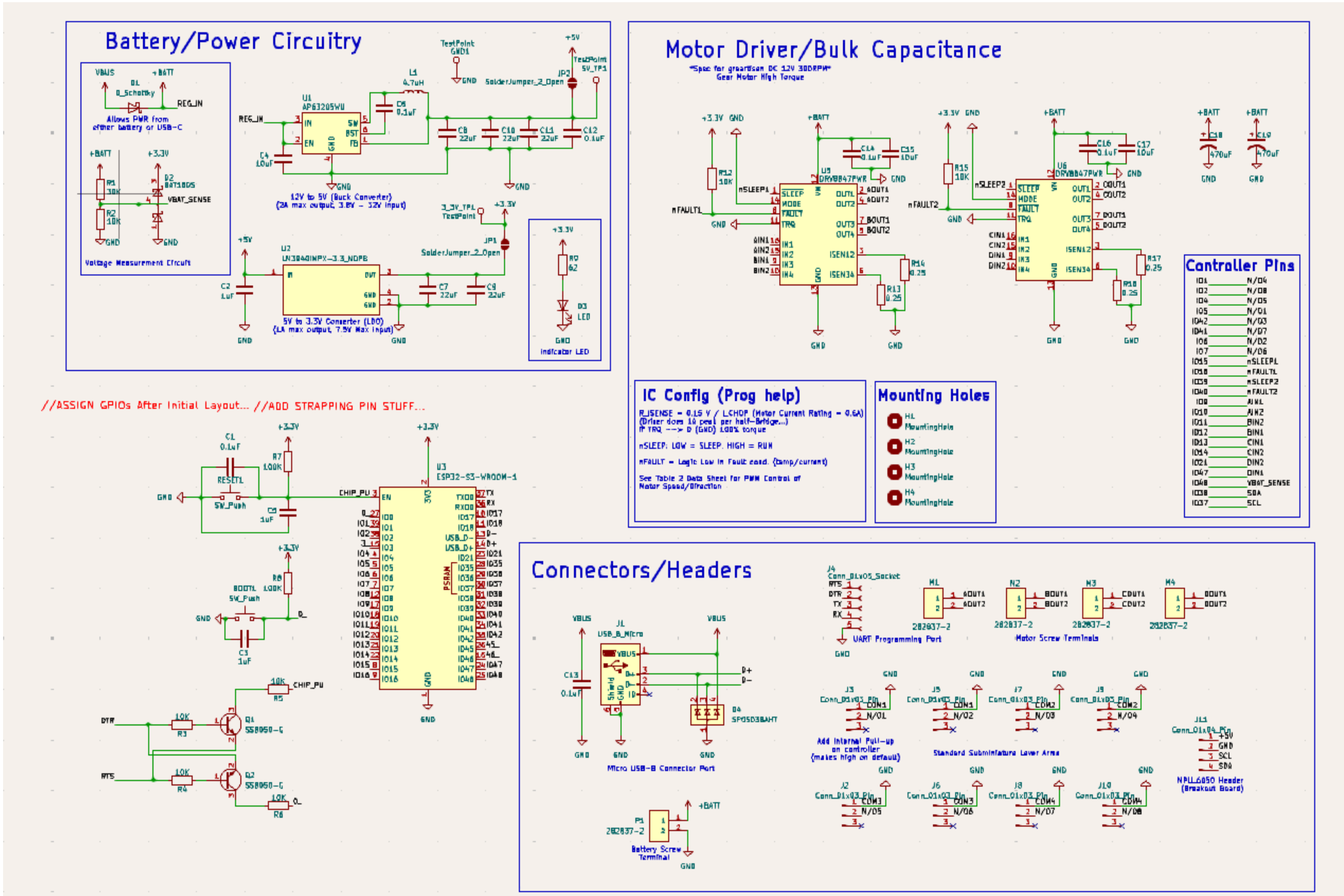

Figure 13

2.2.1 Power Subsystem:

This subsystem manages the power of the Lithium-Ion battery so that each of our boards/peripherals is powered. The 12V battery input will be stepped down to 5V and 3.3V. The 12V out of the battery management system will be directly fed into both of the motor driver ICs as the motor supply voltage, while the 3.3V and 5V will be the logic-level voltage for our other ICs/sensors.

2.2.2 Sensing Subsystem:

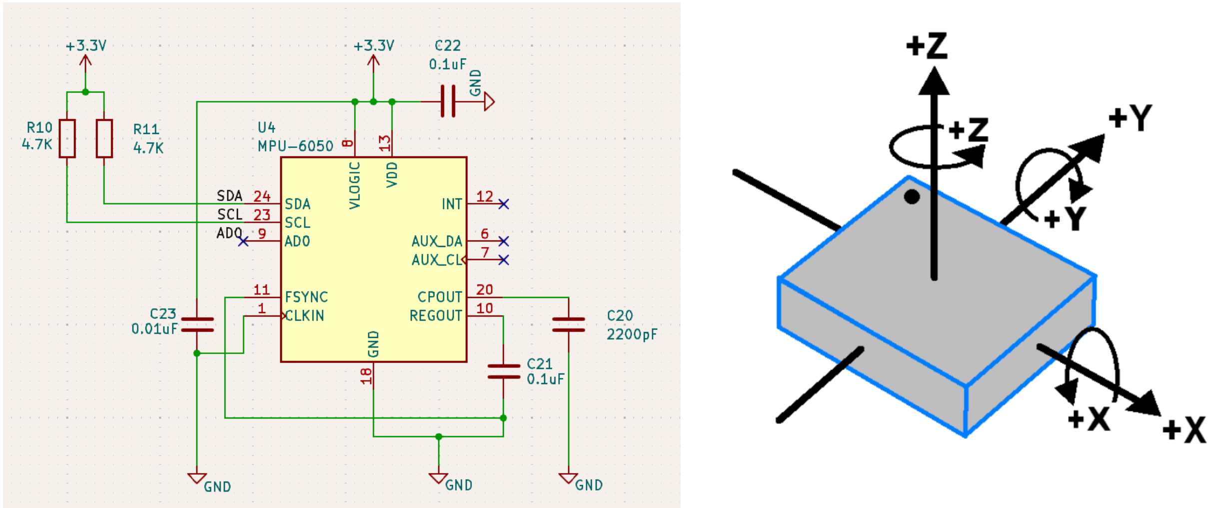

Figure 14: MPU-6050 and Orientation Directions

Our sensing subsystem will consist of our accelerometer to provide orientational data in the *x* and *y* coordinate system, and our limit switches will feel out the operational edges of the board. The accelerometer will detect off-axis movement from the device which will then auto-correct to stay on course(drift correction). The limit switches will be utilized in our edge-detecting algorithm, where if corners/sides are actuated, we will change directions.

2.2.3 Processing Subsystem:

For this project, we will be utilizing the ESP32. The ESP32 serves as the central controller, handling sensor data acquisition, actuator control, and motor driving. It communicates with the IMU using the I2C protocol, where GPIO is assigned to SDA and SCL. This allows for real-time orientation and motion data collection, which is essential for system stability and control. In addition to the IMU, the ESP32 interfaces with eight microswitch actuators via dedicated GPIO pins. These microswitches function as limit switches or event triggers, providing feedback on actuator positions. They are configured with pull-up resistors to ensure reliable state detection. For motor control, the ESP32 generates four PWM signals directed to 2, dual H-driver stepper motor ICs. These signals regulate motor speed and direction, ensuring smooth and precise motion control. The PWM signals are managed using the ESP32's hardware timers to achieve efficient and stable performance.

2.2.4 Motor Subsystem:

This subsystem is responsible for the precise movement of the Board Buddy around the board. This system will move the Board Buddy in an S-formation around the board so that every corner is covered. The motors will also receive data from the ESP32 via PWM. This will allow the Board Buddy to autocorrect in off-axis events and limit switch actuation.

2.2.5 User Interface Subsystem:

This subsystem will allow users to schedule erasings when desired and will allow manual use of the Board Buddy device. It will also store a log of all the uses of the Board Buddy and show the device's status. Another key feature we will include is notifications to let you know before the board is about to be erased, and it will allow the user to cancel the erasing in case a teacher runs past their specified schedule.

2.3 Subsystem Requirements

2.3.1 Power Subsystem:

1. Provide a stable output of 12V +/- 0.1V (1400 mA) (*for motors*)
2. Provide a stable output of 5V +/- 0.1V (3.8 mA) (IMU and limit switch)
3. Provide a stable output of 3.3V +/- 0.1V (740 mA) (Microcontroller and H-Driver ICs)

2.3.2 Sensing Subsystem:

1. The IMU must provide x and y orientation data with an accuracy of ±2°.
2. The system must update orientation estimates at a frequency of at least 1 Hz.

3. The IMU must detect gradual changes in motion (e.g., off-axis drift) and trigger an appropriate response within 200 ms.
4. The IMU data must be processed using a sensor fusion algorithm (e.g., complementary filter, Kalman filter) to reduce drift.
5. Each limit switch must detect contact within 10 ms of impact.
6. The system must stop movement within 50 ms of a limit switch activation.

2.3.3 Processing Subsystem:

1. ESP32 should take in sensor readings/inputs and provide the correct output to motors (within the time restrictions outlined in Section 2.3.2).
2. The UI provided by the configured app should communicate with the ESP32 as outlined in this document with a latency less than 10ms.
3. The flash storage or shared preferences should store at least 10 scheduled erasing events.

2.3.4 Motor Subsystem:

1. Should be able to adjust speed via ESP32 direction based on actuation of lever arms and IMU data.
2. Needs to be able to support an omnidirectional movement across the board.
3. To pass the high-level requirement, the device needs to be able to move at 4.8 inches per second.
    a. If we use 3-inch diameter wheels, we would need 0.51 RPS which is around 30.6 RPMs.

i. This value should be taken as a minimum as we need to further account for magnetic forces and weight.

2.3.5 User Interface Subsystem:

1. A user interface must be created that allows for the board to be scheduled and erased.
2. Must be able to store a history log of erasings in the ESP flash drive or shared preferences.
3. Be able to communicate with the ESP-32 module through Bluetooth.
4. Real-Time Status Changes involving battery life or charging status of the device, determining if the device is currently being used, which would allow us to turn off the device automatically.

2.4 Subsystem Verifications

2.4.1 Power Subsystem:

1. Ensure 12 Volts on Power Rail by verifying with a multimeter underload and confirming its 12±0.1V when motors are running. (+VBATT)
2. Ensure 5 Volts on Power Rail by verifying with a multimeter underload and confirming its 5±0.1V when motors are running.(+5.5V_TP)
3. Ensure 3.3 Volts on Power Rail by verifying with a multimeter underload and confirming its 3.3±0.1V when motors are running. (+3.3V_TP)
4. Test each of these Power Rails under all conditions (ie, Startup, Idle, Operating) in order to assure that the voltages remain stable across all modes.

2.4.2 Sensing Subsystem:

1. Place IMU on a calibrated surface and tilt in known angles in order to verify that the orientation is accurate to ±2°. (GPIO 38, 37)
2. Be able to log data from the IMU in order to confirm updates of orientation data is updating at least ≥1 Hz.
3. Introduce drift off-axis control and confirm that the system is triggered within 200ms.
4. Implement an algorithm in order to show reduction in drift.
5. Test each limit switch by actuating and make sure that the data is received by the ESP 32 within 10ms. (GPIO 1,2,4,5,42,41,6,7)
6. Verify the system halts motor movement within 50 ms of a limit switch activation.

2.4.3 Processing Subsystem:

1. Simulate sensor inputs and confirm ESP 32 produces correct PWM output to motors. (GPIO 9,10,11,12,13,14,21,47).
2. Use Flutter app and send commands to ESP 32 making sure to confirm that connection latency is within 10ms.
3. Be able to schedule and confirm that 10 events are stored in the ESP 32 flash memory or shared preferences with the app are retrieved properly.

2.4.4 Motor Subsystem:

1. Use PWM test signals to control motor speed and direction and be able to detect lever arm and IMU data.
2. Verify that motors can perform omnidirectional movement.

3. Place the device on an educational board and measure travel speed to confirm it reaches at least 4.8 inches per second.

2.4.5 User Interface Subsystem:

1. Verify that the app allows users to schedule and erase the board through user-friendly interactions.
2. Schedule multiple board erasing events through the user interface and confirm all events are correctly saved in ESP32 flash storage or shared preferences. Retrieve and display the saved schedule and history log to verify accuracy.
3. Pair the user interface with the ESP32 via Bluetooth and confirm stable communication.
4. Simulate different device states (charging, low battery, active erasing, idle) and confirm the user interface reflects these status changes in real time.

2.5 Requirements and Verifications Table

Requirement	***Verification***
Power Subsystem	**Power Subsystem**
R1: Provide a stable output of 12V +/- 0.1V (1400 mA) (for motors).	V1: Ensure 12 Volts on Power Rail by verifying with a multimeter underload and confirming its 12±0.1V when motors are running. (+VBATT)
R2: Provide a stable output of 5V +/- 0.1V (3.8 mA) (IMU and limit switch)	V2: Ensure 5 Volts on Power Rail by verifying with a multimeter underload and confirming its 5±0.1V when motors are running.(+5.5V_TP)
R3: Provide a stable output of 3.3V +/- 0.1V (740 mA) (Microcontroller and H-Driver ICs)	V3: Ensure 3.3 Volts on Power Rail by verifying with a multimeter underload and confirming its

	3.3±0.1V when motors are running. (+3.3V_TP)
Sensing Subsystem	**Sensing Subsystem**
R1: The IMU must provide x and y orientation data with an accuracy of ±2°.	V1: Place IMU on a calibrated surface and tilt in known angles in order to verify that the orientation is accurate to ±2°. (GPIO 38, 37)
R2: The system must update orientation estimates at a frequency of at least 1 Hz.	V2: Be able to log data from the IMU in order to confirm updates of orientation data is updating at least ≥1 Hz.
R3: The IMU must detect gradual changes in motion (e.g., off-axis drift) and trigger an appropriate response within 200 ms.	V3: Introduce drift off-axis control and confirm that the system is triggered within 200ms.
R4: The IMU data must be processed using a sensor fusion algorithm (e.g., complementary filter, Kalman filter) to reduce drift.	V4: Implement an algorithm in order to show reduction in drift.
R5: Each limit switch must detect contact within 10 ms of impact.	V5: Test each limit switch by actuating and make sure that the data is received by the ESP 32 within 10ms. (GPIO 1,2,4,5,42,41,6,7)
R6: The system must stop movement within 50 ms of a limit switch activation.	V6: Verify the system halts motor movement within 50 ms of a limit switch activation.
Processing Subsystem	**Processing Subsystem**
R1: ESP32 should take in sensor readings/inputs and provide the correct output to motors (within the time restrictions outlined in Section 2.3.2).	V1: Simulate sensor inputs and confirm ESP 32 produces correct PWM output to motors. (GPIO 9,10,11,12,13,14,21,47).
R2: The UI provided by the configured app should communicate with the ESP32 as outlined in this	V2: Use Flutter app and send commands to ESP 32 making sure to confirm that connection latency is

document with a latency less than 10ms.	within 10ms.
R3: The flash storage or shared preferences should store at least 10 scheduled erasing events.	V3: Be able to schedule and confirm that 10 events are stored in the ESP 32 flash memory or shared preferences with the app are retrieved properly.
Motor Subsystem	**Motor Subsystem**
R1: Should be able to adjust speed via ESP32 direction based on actuation of lever arms and IMU data.	V1: Use PWM test signals to control motor speed and direction and be able to detect lever arm and IMU data.
R2: Needs to be able to support an omnidirectional movement across the board.	V2: Verify that motors can perform omnidirectional movement.
R3: To pass the high-level requirement, the device needs to be able to move at 4.8 inches per second.	V3: Place the device on an educational board and measure travel speed to confirm it reaches at least 4.8 inches per second.
User Interface Subsystem	**User Interface Subsystem**
R1: A user interface must be created that allows for the board to be scheduled and erased.	V1: Verify that the app allows users to schedule and erase the board through user-friendly interactions.
R2: Must be able to store a history log of erasings in the ESP flash drive or shared preferences.	V2: Schedule multiple board erasing events through the user interface and confirm all events are correctly saved in ESP32 flash storage or shared preferences. Retrieve and display the saved schedule and history log to verify accuracy.
R3: Be able to communicate with the ESP-32 module through Bluetooth.	V3: Pair the user interface with the ESP32 via Bluetooth and confirm stable communication.
R4: Real-Time Status Changes involving battery life	V4: Simulate different device states (charging, low

or charging status of the device, determining if the device is currently being used, which would allow us to turn off the device automatically.	battery, active erasing, idle) and confirm the user interface reflects these status changes in real time.

Table 2

2.6 Tolerance Analysis

Throughout brainstorming possible issues to overcome, a major recurring issue was found: the mounting capabilities of the magnets. The team was challenged to run various tests to ensure the theory behind our design was sound. After researching and buying the ideal neodymium magnets for our design, we acquired an IoLab to run various intricate magnetic tests to ensure their capabilities. First, we measured the magnetic force of two magnets and a typical whiteboard (Figure 15).

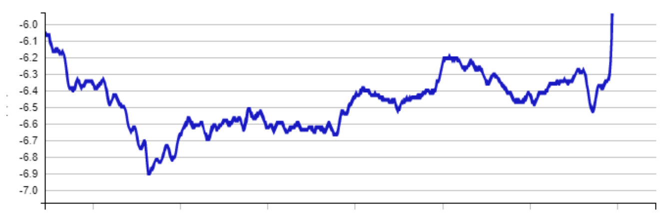

Figure 15

We experimentally received an average of 6.6N between the two magnets and the board, so we implemented Newton's Second Law to determine the mass the magnets can withhold.

$$F = m * a$$

$$m = \frac{6.6N}{9.81 \frac{m}{s^2}} = 672.8 \text{ g}$$

The team was pleased to learn that the design is feasible despite this significant mass, but we still worried that it may not be enough. Therefore, the team procured a third magnet to see if the force would scale linearly with the number of magnets used. The following figure (Figure 16) shows this experiment.

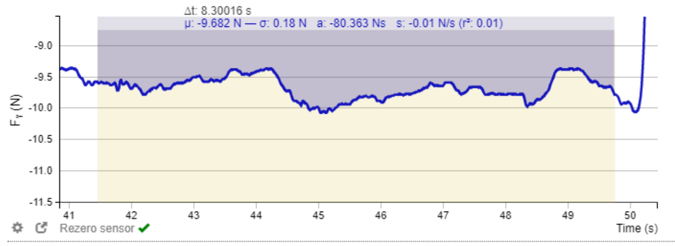

Figure 16

After experimentally receiving an average of 9.6N between the two magnets and the board, we once again applied Newton's Second Law to determine the mass the magnets can withhold.

$$F = m * a$$

$$m = \frac{9.6N}{9.81 \frac{m}{s^2}} = 978.6 \text{ g}$$

Seeing that not only the force scales linearly with the amount of magnets used but also that it only takes three magnets to nearly hold a kilogram, the team was pleased with the theory behind our design (10 magnets total).

$$Total\ Mass\ (10\ magnets) = 3{,}364 \text{ g} = 7.42 \text{ pounds}$$

Another subsystem we are potentially risky is our power subsystem. Our design will employ the use of three different voltage levels: 12V, 5V, and 3.3V with the potential for a lot of power consumed. Ensuring that we can supply the needed current/voltages for the components requiring these power planes is crucial.

Voltage Distribution		
3.3V	**5V**	**12V**
• ESP 32 (240-740 mA) • Dual H bridge Driver(30 µA) x2	• IMU *MPU 6050* (3.8 mA at full pwr) • Microswitch Lever arm (**N/A**)	• Stepper motor x4 (350 mA)

Table 3

$$I_{3.3_{Max}} = 740\, mA + 30\, \mu A(2) \cong 740 mA$$

$$I_{5_{Max}} = 3.8\, mA$$

$$I_{12_{Max}} = 350(4)\, mA \cong 1400\, mA$$

$$I_{TOT} \cong 2143.8 \text{ mA}$$

We also would need a battery that provides us with both longevity and weight savings.

We believe a battery of this size will fit our needs just fine:

12V * 2.1438A = 25.7256 W

Calculating Battery Capacity:

Battery Considerations		
Power Requirement	**Voltage**	**Runtime**
25.7256 W	12 V	30 minutes

Table 4

To determine the required battery capacity for the device, we need to get two key capacity values, Watt-Hours and Amp-Hours.

Battery Capacity (in watt-hours, Wh) = Power (W) × Time (h)

= 25.7256 W × 0.5 h = 12.8628 Wh

$$\text{Battery Capacity (Ah)} = \text{Battery Capacity (Wh)} \div \text{Voltage (V)}$$

$$= 12.8628 \text{ Wh} \div 12 \text{ V} \approx 1.0719 \text{ Ah}$$

Considering Battery Discharge Limits:

To prolong battery life and prevent deep discharge, it's advisable to use only 50% of the battery's capacity. Therefore, the recommended battery capacity should be:

$$\textit{Recommended Battery Capacity} = 1.0719 \text{ Ah} \div 0.5 \approx 2.1438 \text{ Ah}$$

In conclusion, choosing parts that exceed our criteria for voltages/currents is paramount for our design as we are utilizing many high/low power devices.

Final Determinations Following Tolerance Analysis			
Magnetic Consideration	**Weight Consideration**	**Battery Capacity**	**Runtime**
10 magnets 33 Newtons	7.42 pounds 3,364 grams	2.1438 Amp-Hours 25.7256 Watt-Hours	30 minutes

Table 5

3. Cost and Schedule

3.1 Cost Analysis

3.1.1 Labor

Labor Analysis				
	Hourly Wage	Hours to Complete	Calculation	Total
Louie	$55.10	140 hours	$55.10 * 2.5 * 140	$19,285.00
Gabe	$55.10	140 hours	$55.10 * 2.5 * 140	$19,285.00
Alfredo	$55.10	140 hours	$55.10 * 2.5 * 140	$19,285.00
Machine Shop	NA	5 hours	NA	NA
Total				$57,855.00

Table 6

3.1.2 Parts / BOM

Bill of Materials				
Quantity	**Part Number**	**Manufacturer Part Number**	**Description**	**Extended Price USD**
4	SW415-ND	B3S-1000	SWITCH TACTILE SPST-NO 0.05A 24V	2.28
2	296-53425-1-ND	DRV8847PWR	2A DUAL H-BRIDGE MOTOR DRIVER	3.74
2	LM3940IMPX-3.3/NOPBCT-ND	LM3940IMPX-3.3/NOPB	IC REG LINEAR 3.3V 1A SOT-223-4	3.26
2	AP63205WU-7DICT-ND	AP63205WU-7	IC REG BUCK 5V 2A TSOT23-6	2.76
2	311-62ARCT-ND	RC0805JR-0762RL	RES 62 OHM 5% 1/8W 0805	0.20
4	CSR0805FKR250CT-ND	CSR0805FKR250	RES 0.25 OHM 1% 1/4W 0805	1.12
10	RMCF0805FT30K0CT-ND	RMCF0805FT30K0	RES 30K OHM 1% 1/8W 0805	0.25
5	A113320-ND	282837-2	TERM BLK 2P SIDE ENT	5.60

			5.08MM PCB	
2	SRN6045TA-4R7MCT-ND	SRN6045TA-4R7M	FIXED IND 4.7UH 4.5A 26 MOHM SMD	0.88
2	S6103-ND	PPTC051LFBN-RC	CONN HDR 5POS 0.1 TIN PCB	0.84
2	3147-B1701UYG-20D000114U1930CT-ND	B1701UYG-20D000114U1930	LED YLW-GRN DIFFUSED 0805 SMD	0.20
2	1727-5451-1-ND	BAT160S,115	DIODE ARRAY SCHOT 60V 1A SOT-223	1.62
2	P15392CT-ND	EEU-FR1V471LB	CAP ALUM 470UF 20% 35V RADIAL TH	1.34
10	1276-1274-1-ND	CL10A226MP8NUNE	CAP CER 22UF 10V X5R 0603	0.59
6	C0603C104J4RACTU	C0603C104J4RACTU	0.1 µF ±5% 16V Ceramic Capacitor X7R 0603 (1608 Metric)	0.72
3	CL10B105KA8NNNC	CL10B105KA8NNNC	1 µF ±10% 25V Ceramic Capacitor X7R 0603 (1608 Metric)	0.18
1	641-1707-2-ND	CDBA540-HF	DIODE SCHOTTKY 40V 5A DO214AC	0.14241
1	1965-ESP32-WROOM-32-N4DKR-ND	ESP32-WROOM-32-N4	RF TXRX MOD BLUETOOTH WIFI SMD	6.56
1	Case	TBD	TBD	TBD
4	Omni Wheels	TBD	TBD	TBD
4	DC Motors	Greartisan DC 12V 300RPM	Greartisan DC 12V 300RPM Gear Motor High Torque Electric Micro Speed Reduction Geared Motor Eccentric Output Shaft 37mm Diameter Gearbox	60.54
30	Neodymium Magnets	MIN CI Super Strong Neodymium Magnet Bar	MIN CI Super Strong Neodymium Magnet Bar, 40 X 10 X 3 mm Powerful Rare Earth Magnets Strip Heavy Duty	24.50
5	PCBs	PCB	PCBWay	5.00
TOTAL	TOTAL	TOTAL	TOTAL	123.51

Table 7

3.2 Schedule

Team 34 : March 2025										
	3/1	3/4	3/5	3/6	3/8	3/11	3/12	3/14	3/25	3/31
Louie	Prepare App for Demo	TA Meet	Team Eval.	Design Doc	Prepare Board for Demo	TA / Blevins Meet	Demo	Get PCB	TA Meet / Solder and Test	Prog. Report
Alfredo	Prepare App for Demo	TA Meet	Team Eval.	Design Doc	Prepare Board for Demo	TA / Blevins Meet	Demo	Get PCB	TA Meet / Solder and Test	Prog. Report
Gabe	Order PCB	TA Meet	Team Eval.	Design Doc	Prepare BOM for parts	TA / Blevins Meet	Demo	Get PCB	TA Meet / Solder and Test	Prog. Report

Table 8

Team 34 : April 2025									
	4/1	4/3	4/4	4/8	4/10 - 4/14	4/15	4/18 - 2/21	4/22	4/25
Louie	TA Meeting	Test Board	Integrate	TA Meet	App Board Integration / Debugging	TA Meeting	Final Adj. Code	Mock Demo	Final Demo
Alfredo	TA Meeting	Solder Board	Integrate	TA Meet	App Board Integration / Debugging	TA Meeting	Final Adj. Code	Mock Demo	Final Demo
Gabe	TA Meeting	Solder Board	Test Board	TA Meet	App Board Integration / Debugging	TA Meeting	Final Adj. Board	Mock Demo	Final Demo

Table 9

4. Ethics and Safety

4.1 Ethics and Safety Concerns

IEEE Code of Ethics (IEEE Code of Ethics, 2025)

[I.1] In regards to IEEE Code I.1, the team must ensure the safety and privacy of the public. To do this, we must take into account the privacy of the device application so we do not release sensitive information. Furthermore, regarding the safety of the public, we must take into account the magnetic aspect of the project. We must ensure that the magnet is not strong enough to damage electronics, especially medical electronics. On the other hand, we must ensure that the magnet is strong enough to hold the device so as to not fall and injure anyone.

[I.5] Pertaining to the IEEE Code I.5, we must be diligent in seeking and accepting honest criticism of our work. Moreover, we must ensure that we state realistic claims of our device's capability while properly crediting the work of others. To do this, we will reach out to the course assistance networks as often as we need while recording honest data to be published with our work. In publishing this work, we will ensure that references are always given to any party that assisted.

ACM Code of Ethics (ACM Code of Ethics, 2025)

[1.6] A particular ACM Code of Ethics, Code 1.6, will be of significant importance in this project. As this device will have Bluetooth capabilities, we must ensure that the application connection respects the privacy of the user. We must be sure to only use the minimum amount of personal information to have the application work as desired.

University of Illinois at Urbana-Champaign Student Code of Ethics (Student Code, 2025)

[1.4] Article 1 Part 4, Academic Integrity, is a code that the team strives to uphold. In this project, the same as with many projects before, we must uphold academic integrity. We must ensure that we accredit any affiliated parties or released works that have assisted us.

4.2 Safety Documentation

[Stanford] A large number of Neodymium Magnets are being activated while this product is in use. Documentation for the safety of use of these magnets is provided in the references. The team will follow these guidelines to ensure the safe creation and use of the product.

[Harvard] A Lithium Ion Battery is being charged and discharged while this product is in use. Documentation for the safety of use of these batteries is provided in the references. The team will follow these guidelines to ensure the safe creation and use of the product.

5. References

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