

P3 Report : Design and Development of a campus micro-mobility solution for IIT campus students, alternative to cycles, buggy and autorickshaws — EV personal micro-mobility for IIT Bombay campus commute

Guided by
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Project by
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—22M2225
M.Des Industrial Design 2024'

NEOSCOOT

NEOSCOOT



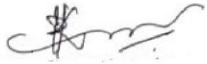
Prince R

Approval Form

This is to certify that the Industrial Design project entitled " **Neoscoot : A Personal EV micro-mobility for IIT Bombay campus commute**" by **Prince R**, 22M2225 is approved for partial fulfilment for the Master of Design Degree in Industrial Design.

Digital Signature
Sandesh R (i07139)
01-Aug-24 11:15:57 AM

Signature of Guide
[Prof Sandesh R]



Signature of Internal Examiner



Signature of External Examiner



Signature of Chairperson

Declaration Form

I, **Prince R, 22M2225**, declare that this written report represents my ideas in own words, and where other' ideas or words have been included I have adequately cited and referenced the original sources.

I also declare that I have adhered to all the principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.

I understand that any violation of the above will be caused for disciplinary action by the institute and can also evoke penal action from the source. From which proper permission has not been taken or improperly been cited.

A handwritten signature in black ink, appearing to read 'Prince', with a stylized flourish extending from the end.

Signature of Student

Prince R
22M2225

Industrial Design 24'

Acknowledgment

I would like to express my heartfelt gratitude to my guide **Prof. Sandesh R**, for his essential assistance throughout the project. Special thanks to professors of Industrial Design for their critics and guidance. I am also grateful to all the instructors, staffs, and students at Industrial Design Center (IDC) for their assistance, advice, and suggestions. I would like to thank **Prof. B.K. Chakravarthy** and **Prof. Sugandh Malhotra** for their guidance in the making of this Project. Special Thanks to Nikhil Sir and Kailash Sir for helping me with the prototyping.

I thank my **Parents**, for all the unwavering support and being my backbone. Finally, I'd like to express my love and gratitude to my **Family and Friends of Industrial Design Batch of 2024 and 2025** for their constant support.

Abstract

This project abstract outlines an innovative approach to redefining campus commuting at IIT Bombay by introducing a personalized mobility solution tailored to the campus's unique needs and environment. The bustling and dynamic campus presents challenges such as time-consuming commutes, energy-draining journeys, and parking limitations, which current transportation options struggle to fully address. To enhance the overall campus experience, this project aims to develop a new mobility device that seamlessly integrates with existing services like E-Buggy and auto rickshaws while offering enhanced convenience and sustainability.

The proposed solution will be meticulously designed to align with IIT Bombay's ethos of innovation and academic excellence. Emphasis will be placed on user-centric design, ensuring the mobility device caters to the diverse needs of students, faculty, and staff navigating the campus daily. Sustainability will be a key consideration, with the goal of reducing energy consumption and carbon footprint compared to conventional transportation methods. The project will explore various options, from e-bikes to innovative concepts, to identify the most suitable and practical solution.

By focusing on innovation, sustainability, and affordability, this project seeks to redefine campus mobility and contribute to a more efficient and enjoyable commuting experience for the IIT Bombay community. The resulting mobility solution will not only address current challenges but also pave the way for future advancements in personal transportation within academic campuses. Through collaboration and interdisciplinary research, this project aims to set a new standard for campus mobility solutions, embracing technological progress while maintaining practicality and accessibility.



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INTRODUCTION

01

Introduction

IIT Bombay stands as a beacon of academic excellence, situated within a vibrant ecosystem that fosters innovation and intellectual growth. The campus, sprawling with diverse academic and residential areas, is interconnected by a network of roads and pathways. To facilitate efficient mobility for its bustling community of students, faculty, and staff, the campus currently relies on a mix of transportation options including E-Buggy services, auto rickshaws, and bicycles. While these modes of transport serve the community well, challenges such as time-consuming commutes, limited parking, and the need for sustainable alternatives persist.

Existing transportation systems within the campus, such as the E-Buggy service, have proven effective but may face constraints during peak hours or in areas with restricted accessibility. Additionally, traditional auto rickshaws and bicycles, while reliable, may not fully meet the evolving mobility needs of the IIT Bombay community. As the campus continues to grow and evolve, there is a compelling opportunity to introduce a new personal mobility solution that complements existing services and enhances the overall commuting experience.

This project seeks to leverage innovation and design to address these challenges by developing a novel personal mobility device tailored specifically to the needs of IIT Bombay. The project builds upon the rich culture of technological advancement and problem-solving inherent to the institution, aiming to redefine campus mobility through a blend of creativity, sustainability, and practicality. By understanding the unique context and requirements of the campus, this initiative aims to contribute to a more seamless, efficient, and enjoyable commuting experience for all members of the IIT Bombay community.



Campus Area: 24000
Number of Roads: 24000
Main Roads: 24000
Maximum Slope: 24000

Motivation to Pick this Topic

"As a frequent cyclist on the IIT Bombay campus, I have experienced firsthand, the challenges associated with navigating its sprawling landscape. The campus's sloping roads can be physically demanding, often leaving cyclists tired and fatigued after pedaling uphill stretches. This issue is exacerbated by the need to commute between various academic and residential areas, making efficient mobility a priority for students and faculty alike. Furthermore, relying on the E-Buggy service or auto rickshaws can result in considerable wait times, especially during peak hours, which can be frustrating when time is of the essence.

The existing transportation infrastructure, while diverse and functional to some extent, falls short of fully meeting the dynamic needs of the campus community. For cyclists like myself, the physical exertion required to traverse the campus can be a deterrent, particularly on hot days or when navigating steep inclines. This highlights the necessity for a more accessible, energy-efficient, and convenient mobility solution that integrates seamlessly with existing services like the E-Buggy while offering greater flexibility and autonomy to users.

By addressing these pain points through innovative design and thoughtful engineering, the goal is to enhance the overall commuting experience at IIT Bombay. A personalized mobility solution that minimizes physical strain, reduces waiting times, and provides a reliable means of transportation across the campus will not only improve daily convenience but also contribute to a more sustainable and cohesive mobility ecosystem. This project aims to prioritize user comfort and efficiency, drawing inspiration from personal experiences to inform the development of a tailored mobility solution that aligns with the ethos of innovation and excellence at IIT Bombay."



Micro-Mobility

Micro mobility refers to a category of transportation that involves small, lightweight vehicles designed for short-distance trips. These vehicles are typically powered by human effort (such as pedaling or kicking), electricity (battery-powered motors), or a combination of both. Micro mobility options are intended for use over relatively short distances within urban or suburban environments, providing convenient, efficient, and environmentally friendly alternatives to traditional modes of transportation like cars or buses.

Key characteristics of micro mobility include:

Small Size and Lightweight: Micro mobility vehicles are compact and lightweight, making them easy to maneuver through crowded urban areas and allowing for convenient storage or parking.

Short-Distance Travel: These vehicles are ideal for short trips, such as commuting to work, running errands, or navigating within a neighborhood or city district.

Eco-Friendly: Many micro mobility options are considered environmentally friendly, emitting fewer greenhouse gases compared to cars and helping reduce traffic congestion and air pollution.

Variety of Vehicle Types: Micro mobility encompasses a range of vehicle types, including electric scooters, bicycles, electric skateboards, hoverboards, and even small electric cars designed for urban use.

Shared Mobility Services: Micro mobility often involves shared mobility services, where users can rent or share vehicles for short periods using smartphone apps. This allows for flexible, on-demand transportation options without the need for ownership.

Micro mobility has gained popularity in urban areas around the world as cities strive to address transportation challenges such as congestion and pollution. It offers individuals a convenient and sustainable way to move around, particularly for short trips where using a private car may be unnecessary or impractical. However, challenges related to safety, infrastructure, regulations, and integration with existing transportation systems remain important considerations in the development and adoption of micro mobility solutions.



Campus Demography

Total Population - 13429
Number of Male - 10439
Number of Female - 2990
Number of PwD -
Number of Masters Students - 3192
Number of Bachelors Students – 5481
Number of PhD Students - 4127



Existing means of Transportation



01

Cycles

Many students rely on traditional bicycles for their daily commute, embodying a blend of simplicity and practicality.



02

E-Buggy Service

The campus is served by an in-built electric buggy service, providing a convenient and eco-friendly mode of transport with fixed routes.



03

Auto Rickshaws

Regular paid auto-rickshaws offer an alternative for those seeking personalized commuting options within the campus.

Campus Roads

Number of Road: 7-8

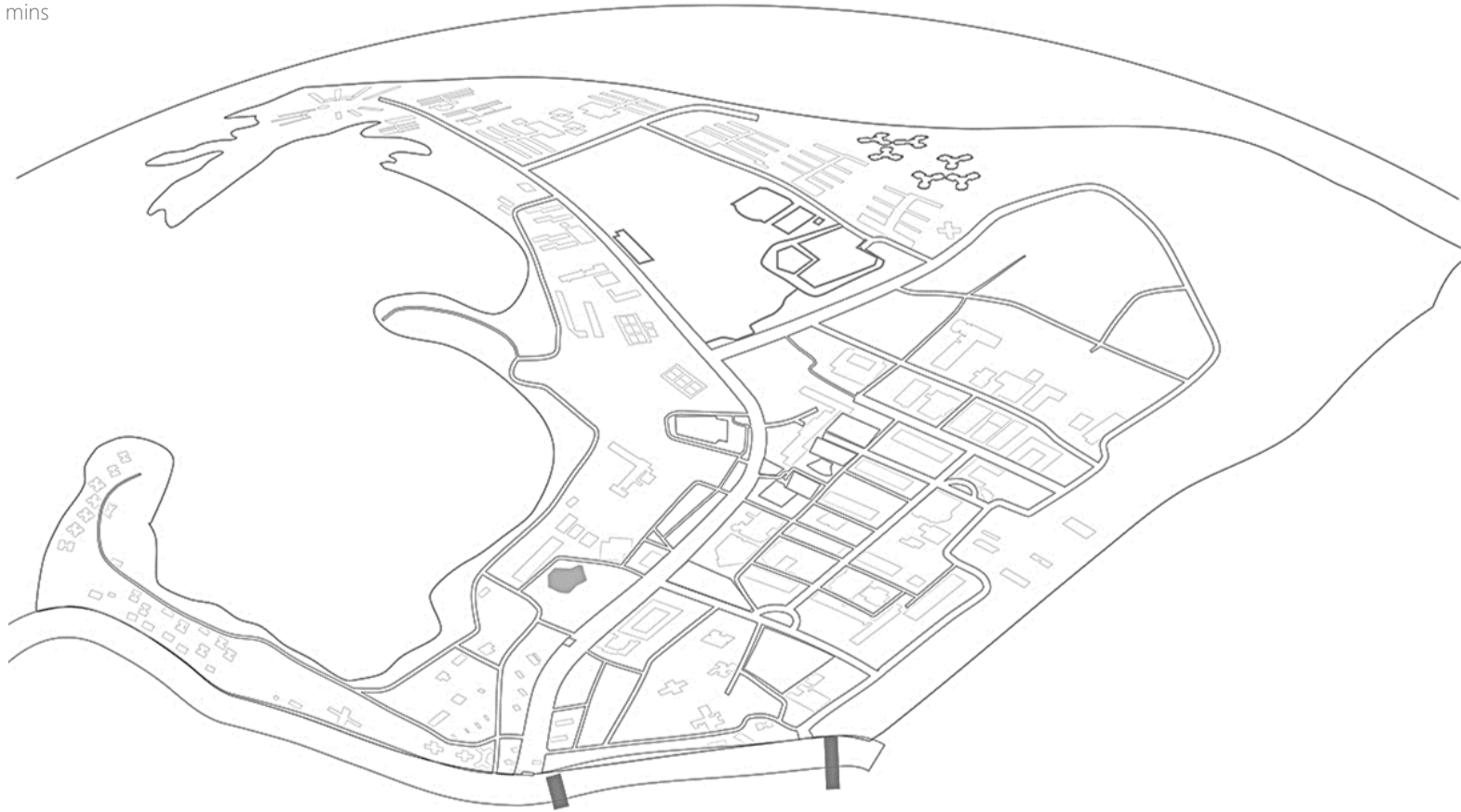
Longest Road: Main Gate - Hostel 12

Dense Route: Main Gate - Hostel 12

Sloppy Route: Main Gate - Hostel 12

Time for Longest Route: 12 mins

Average Time: 7 mins



The Design Challenge

“

While these existing options cater to diverse commuting needs, there is an opportunity to introduce a new personal micro-mobility device that aligns seamlessly with the ethos of IIT Bombay. The Challenge aims to explore and design a novel personal mobility solution, whether it be an E-Bike, E-Scooter, Skateboard, or an entirely innovative concept.

”

PROJECT PLANNING

02

Product Development Process

The typical product development process comprises six distinct phases. It commences with a planning phase that serves as a bridge to advanced research and technology development endeavors. During this phase, the project's mission statement is formulated, serving as a foundational input for commencing the concept development stage. This mission statement acts as a guiding beacon for the development team throughout the process.

Following the planning phase, the concept development phase ensues, where ideas are explored and refined to conceptualize the product. This phase is pivotal in translating the project's mission into tangible design concepts. Subsequently, the design and development phase begins, focusing on transforming the selected concept into a functional prototype or product. This stage involves rigorous testing, optimization, and iteration to achieve the desired performance and specifications.

After design and development, the product undergoes thorough testing and validation in the testing and validation phase to ensure it meets quality standards and user requirements. Once validated, the product proceeds to the production phase, where it is manufactured at scale for distribution. Finally, the product launch marks the culmination of the development process, with the product becoming available for purchase in the marketplace.

In essence, the product development process is a structured journey that starts with strategic planning and culminates in a successful product launch, guided by the project's mission statement and driven by iterative design, development, and validation activities. Each phase plays a crucial role in transforming innovative ideas into market-ready products.

The product development process comprises several sequential phases that guide the progression from initial planning to product launch and refinement:

1. **Planning (Phase Zero):** This phase precedes project approval and involves identifying opportunities aligned with corporate strategy. It includes assessing technology developments and market objectives to formulate a project mission statement. This statement specifies the target market, business goals, key assumptions, and constraints
2. **Concept Development (Phase One):** In this phase, the needs of the target market are identified, and alternative product concepts are generated and evaluated. Specific concepts are selected for further development based on form, function, features, and economic justification.
3. **System-Level Design (Phase Two):** Here, the product architecture is defined, and the product is decomposed into subsystems and components. Key components are preliminarily designed, and responsibilities for detailed design are allocated. Initial plans for production and assembly are also outlined.
4. **Detail Design (Phase Three):** This phase involves specifying the geometry, materials, and tolerances of all unique parts, as well as identifying standard parts to be purchased. Production processes and tooling are planned, and control documentation is developed, including drawings or computer files describing parts and production tooling.
5. **Testing and Refinement (Phase Four):** Multiple preproduction versions of the product are constructed and evaluated. Alpha prototypes, using production-intent parts, test the functionality and customer satisfaction. Beta prototypes, built with intended production processes, undergo extensive internal and customer testing to refine performance and reliability.
6. **Production Ramp-Up (Phase Five):** During this phase, the product is manufactured using the intended production system to train the workforce and identify any remaining production issues. Products produced in this phase may be evaluated by preferred customers before full-scale production and distribution.

Design : Generic Product Development Process

01

Planning

Explore product platform and architecture. Evaluate emerging technologies.

02

Concept Development

Explore the feasibility of product concepts. Create industrial design concepts. Construct and test experimental prototypes.

03

System Level Design

Refine product architecture. Define major subsystems and interfaces. Enhance industrial design. Initiate preliminary component engineering.

04

Detail Design

Define part geometry. Select appropriate materials. Specify tolerances. Finalize industrial design control documentation.

05

Testing & Refinement

Evaluate overall performance, reliability, and durability. Obtain necessary regulatory approvals. Assess environmental impact. Implement design modifications based on testing and feedback.

06

Ramp-Up

Evaluate early production output.

USER RESEARCH

03

My Story

Navigating around IIT Bombay campus can be quite a workout, especially with all those uphill slopes making me break a sweat on my trusty Firefox bicycle. Don't get me wrong, the downhill rides are pretty enjoyable, but those uphills can be a bit daunting!

When I'm not cycling, I often find myself waiting around a lot for auto-rickshaws or campus buggies. It's frustrating when you're in a rush or just want to get to your destination without a long wait. Plus, the auto charges can add up, and the buggies always seem to be packed when I need them the most.

One big issue I face is the lack of shelter for my bike. My Firefox bicycle means a lot to me, and leaving it out in the open leaves me worried about the weather and potential theft.

To make my life easier on campus, I've been thinking about getting an electric bike or scooter with pedal-assist. That way, I can breeze through those slopes without working up too much of a sweat. I'm also keen on pushing for better buggy services and more secure bike parking areas on campus.

Exploring newer and innovative mobility solutions could be the key to revolutionizing campus commuting at IIT Bombay! While traditional options like bicycles, auto-rickshaws, and campus buggies serve their purpose, embracing cutting-edge mobility technologies can elevate our experience and make life on campus even more enjoyable. Imagine zipping around on a sleek electric skateboard or a futuristic self-balancing personal transporter. These next-generation mobility devices are not only compact and efficient but also incredibly cool and fun to use. They offer a fresh alternative to traditional modes of transportation, adding a touch of excitement to our daily commute.

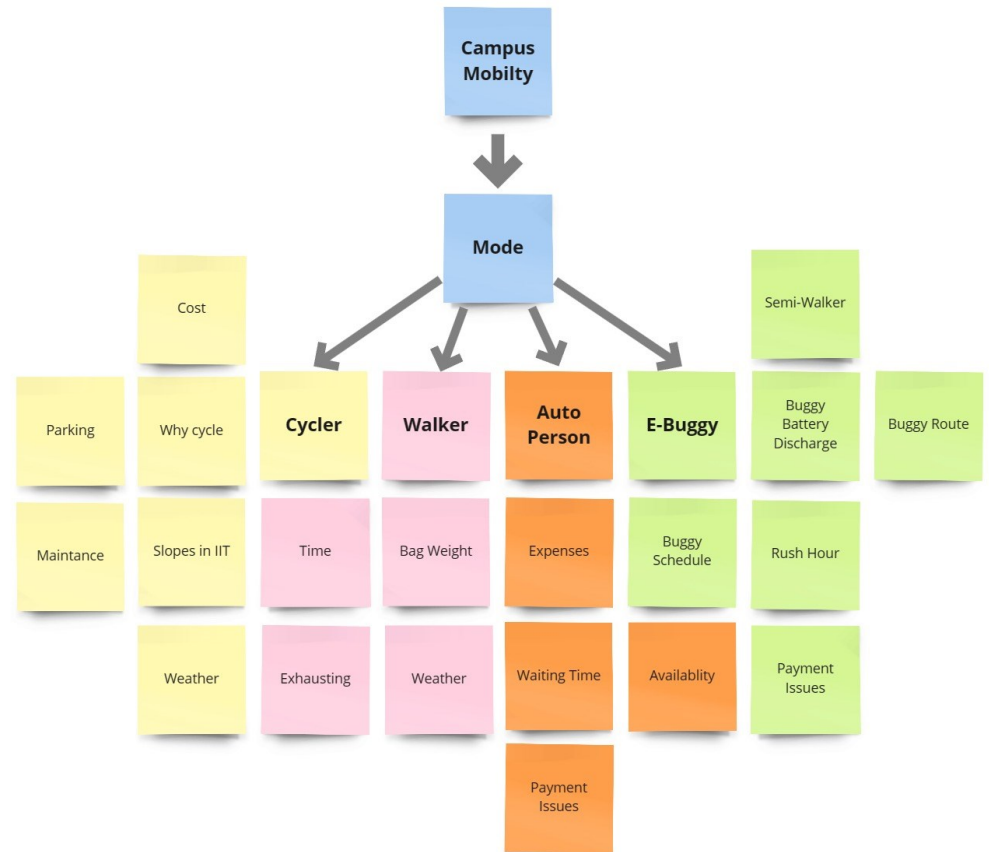
Moreover, embracing new mobility options aligns perfectly with our commitment to sustainability. Electric vehicles and innovative transporters are environmentally friendly, producing zero emissions and reducing our carbon footprint. By adopting these modern mobility solutions, we can contribute to a greener campus environment and set an example for sustainable living.



Survey A

Survey A , is a beginner survey to get familiarities with the users, their mode of transport, preferences, Affordability

Sample Size : 22



Survey A Questionnaire

Here are glimpse of few questions asked.

15. Did you opt for **second-hand** cycle? *

Check all that apply.

- ☐ Yes , to save cost
☐ Yes, I didn't want to spend time finding the right cycle.
☐ No, I believe in buying new, to start fresh!
☐ No, because second hand products, usually have issues with Aesthetics and Function

23. Considering the cost estimates,

A Trip (to and fro) cost for **Auto Rickshaw** is ₹23 + ₹23 = ₹46. **So, for 2 years in college is ₹33580 and ₹67160 for 4 years.**

A Trip (to and fro) cost for **E-Buggy** is ₹10 + ₹10 = ₹20. **So, for 2 years in college is ₹14600 and ₹29200 for 4 years.**

What price range do you think should a personal commuting device should fall into which will make you consider for a purchase?

Mark only one oval.

- ☐ 5000-7000
☐ 7001-10000
☐ 10001-15000
☐ 15001-17000
☐ 17001-20000
☐ 20001-25000

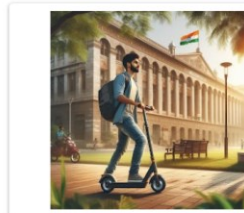
27. What are the reasons you think they are the future of **IIT Bombay Campus Commute?** (Please select only 3 options) *

Check all that apply.

- ☐ Ethos of IIT Bombay as Technologically Advanced and Futuristic
☐ Effortless
☐ Agility
☐ Stylish and Modern
☐ Compact

26. Which **micromobility** devices do you think is **future of campus personal commuting in IIT Bombay Campus?** (Please select only 2 options)

Check all that apply.



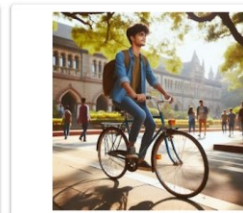
☐ Electric Kick-Scooter



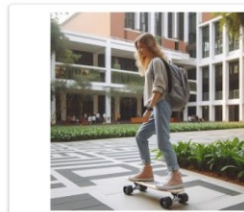
☐ Segway



☐ Hoverboards



☐ Bicycle



☐ Skateboards

- * 22. Common Problems faced by E-Buggy, Auto Rickshaw users are: **Unavailability during rush hours, Travel routes, Expenses, Waiting time.** *

Why you opted not to own a cycle?

Check all that apply.

- ☐ Investment and cost problem
☐ Too much efforts riding a cycle
☐ Maintenance and parking issues
☐ Duration of usage is very less because of my academic period. (i.e., Masters is only 2 years)

30. What price range do you think should this personal commuting device should fall into which will make you consider for a purchase? *

Mark only one oval.

- ☐ 7001-10000
☐ 10001-15000
☐ 15001-17000
☐ 17001-20000
☐ 20001-25000

Thats all ! :)

Thank you for taking the time to participate in this survey. Your feedback is valuable in shaping the future decisions. I greatly appreciate your contribution to my research and design!



Survey A.pdf

Insights from Survey A

Insights from Survey A highlight various challenges and preferences related to campus commuting. These insights shed light on the key pain points experienced by students in campus commuting and underscore the need for innovative solutions to enhance mobility, reduce waiting times, and address weather-related challenges. The preferences expressed towards future commuting modes emphasize a shift towards more efficient and sustainable transportation options on campus.

Perception of Personal Transportation

Students perceive not having personal transportation as a waste of money and time, emphasizing the importance of agility in campus mobility. Students strongly value personal transportation on campus, considering it essential for saving time and money while providing autonomy and convenience. Owning a mode of transport

allows students to navigate campus independently, avoiding uncertainties associated with waiting times and availability of communal services. This perception highlights a growing preference for personalized mobility solutions that enhance flexibility and control in daily commuting experiences.

Preferred Modes for Future Campus Commute

Respondents foresee bicycles, e-scooters, and Segways as the preferred modes for future campus commuting due to their convenience, efficiency, and versatility in navigating campus terrain. These options offer agile and environmentally friendly alternatives, aligning with the trend towards sustainable transportation solutions. The envisioned shift underscores a desire for personalized mobility that enhances accessibility and promotes active lifestyles among campus communities.



E-Buggy User's Issues

Users of the campus E-Buggy service face challenges such as high waiting times, limited availability during peak hours, and the inability to reach exact destinations due to fixed routes.



Auto-Rickshaw User's Issues

Similar to E-Buggy users, auto-rickshaw commuters experience long waiting times, limited availability during peak hours, and overall high costs.



Issues Encountered by Cyclists

Cyclists struggle with the campus's steep slopes, leading to difficulties in riding. Moreover, cycling can be physically demanding, resulting in sweat and body odor, which can be unpleasant when entering class. Additionally, rainy weather exacerbates the challenges of cycling.



Challenges Faced by Walkers

Walking on campus is perceived as time-consuming and exhausting, especially during adverse weather conditions when roads become muddy.

User Persona



Commuter Charlie

25, Male
ID, IDC

Transportation Habits

Commutes daily from a residential area to multiple locations on campus.
Prefers a mode of transportation that offers a good balance between speed and convenience.

Challenges

Finds the current electric buggy service inconvenient due to fixed routes and schedules.
Auto-rickshaw is considered expensive for daily use.

Preferences

Interested in a personal transportation device that is agile, easy to maneuver, and can adapt to various routes.
Values a sustainable and eco-friendly mode of transportation.



Eco-Conscious Emma

19, Female
Aerospace Engineering

Cares deeply about environmental impact.
Currently walks or bikes to reduce carbon footprint.

Avoids campus-provided services due to their carbon footprint.
Desires a personal transportation solution that aligns with sustainable living practices.

Interested in an electric device with eco-friendly materials.
Values a compact and lightweight solution that can easily be stored.



Busy Bryan

25, Male
Business Administration

Commutes to and from campus multiple times a day for classes, part-time job, and meetings.
Time-efficient commuting is a priority.

Current campus services are often overcrowded, leading to delays.
Auto-rickshaw is a bit expensive for daily use.

Interested in a personal transportation device that is fast, efficient, and easy to use.
Values a foldable and portable solution for easy storage.



Social Sarah

29, Female
PhD Embedded Systems

Enjoys socializing and exploring different parts of the campus.
Prefers a mode of transportation that allows interaction with friends during commuting.

Finds the electric buggy service restrictive in terms of socializing during transit.
Auto-rickshaw is often perceived as isolating.

Interested in a personal transportation device that is social, fun and easy to use. Values a design that encourages interaction and a sense of community

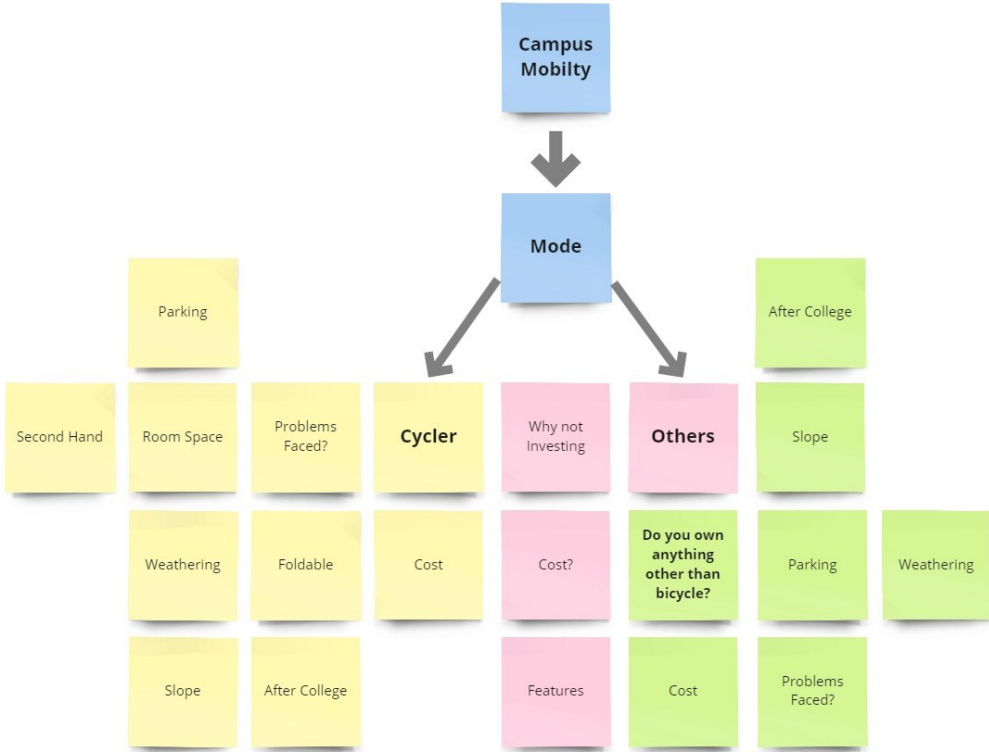
Survey B

Navigating around IIT Bombay campus can be quite a workout, especially with all those uphill slopes making me break a sweat on my trusty Firefox bicycle. Don't get me wrong, the downhill rides are pretty enjoyable, but those uphill can be a bit daunting!

When I'm not cycling, I often find myself waiting around a lot for auto-rickshaws or campus buggies. It's frustrating when you're in a rush or just want to get to your destination without a long wait. Plus, the auto charges can add up, and the buggies always seem to be packed when I need them the most.

One big issue I face is the lack of shelter for my bike. My Firefox bicycle means a lot to me, and leaving it out in the open leaves me worried about the weather and potential theft.

Sample Size : 20



Survey B Questionnaire

Here are glimpse of few questions asked.

23. Consider the design and aesthetics of the following options. Rank them based on what you find most aesthetically pleasing: *

Mark only one oval per row.

	Bicycle	Scoter	Skateboard	Segway	Hoverboard	Other
Rank 1	☐	☐	☐	☐	☐	☐
Rank 2	☐	☐	☐	☐	☐	☐
Rank 3	☐	☐	☐	☐	☐	☐
Rank 4	☐	☐	☐	☐	☐	☐
Rank 5	☐	☐	☐	☐	☐	☐
Rank 6	☐	☐	☐	☐	☐	☐

24. Consider the safety and usability of the following options. Rank them based on what you find most safe and ease of use: *

Mark only one oval per row.

	Bicycle	Scoter	Skateboard	Segway	Hoverboard	Other
Rank 1	☐	☐	☐	☐	☐	☐
Rank 2	☐	☐	☐	☐	☐	☐
Rank 3	☐	☐	☐	☐	☐	☐
Rank 4	☐	☐	☐	☐	☐	☐
Rank 5	☐	☐	☐	☐	☐	☐
Rank 6	☐	☐	☐	☐	☐	☐

22. Which of the following modes of transportation do you think is the coolest to use on campus? *

Check all that apply.



☐ Bicycle



☐ Scooter



☐ Skateboard



☐ Segway



☐ Hoverboard



☐ Other

27. What factors make a mode of transportation cool to use on campus? (e.g., brand image, customization options, technology integration) *



Insights from Survey B

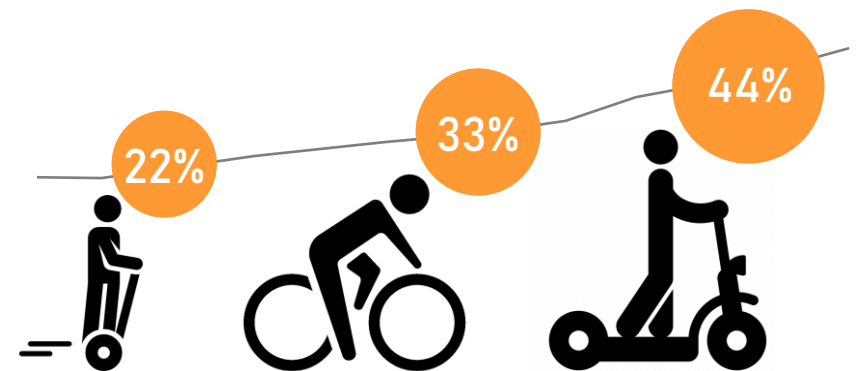
The ethos of IIT Bombay reflects a culture deeply rooted in technological advancement and a forward-thinking approach. **As a premier institution known for innovation and cutting-edge research, IIT Bombay embodies a spirit of embracing modernity and pushing boundaries in technology.** This ethos extends to various facets of campus life, including transportation, where there is a distinct preference for solutions that are not only efficient but also embody the principles of innovation and progress.

In the context of personal transportation, IIT Bombay students and community members emphasize the importance of affordability and accessibility. The preference for solutions priced around **₹15,000 to ₹17,000** underscores the practicality and pragmatism inherent in the campus culture, where value for money is a key consideration. Coupled with the institution's technological ethos, there is an expectation that personal transportation options should integrate seamlessly with modern technologies and offer innovative features that enhance user experience.

Furthermore, the desire for motor assistance, compactness, and a stylish, futuristic design reflects IIT Bombay's inclination towards solutions that are not only functional but also aesthetically appealing. The campus community values products that symbolize progress and modernity, embodying the spirit of technological excellence that defines the institution. This ethos drives the demand for e-scooters, Segways, and e-cycles as future modes of transportation, each offering a blend of efficiency, innovation, and style that resonates with the values of IIT Bombay.

Attributes

Futuristic
Technological
Stylish
Cool
Compact



PROBLEM STATEMENT

04

Problem Statement

01

Time
Time-consuming
campus mobility

02

Energy
Energy-draining
transportation options

03

Balancing
Difficulty in balancing
during transport

04

Sloppy Roads
Navigating campus
slopes effectively

05

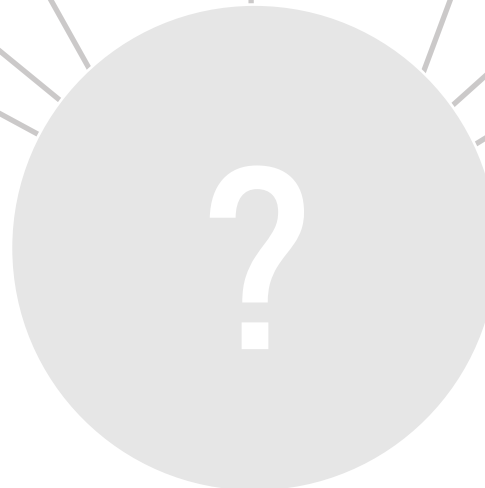
Boring
Need for a futuristic
mode of personal
transport

06

Affordable
Compact and affordable
transportation solution
required

07

Parking
Hostel parking issues
due to limited space



METHODOLOGY

05

Approaching the Project

When approaching a product design project, there are typically two primary methods or approaches that designers and teams can utilize: problem-driven design and solution-driven design. Both approaches have their merits and can be valuable depending on the project context and goals. **In practice, a hybrid approach that combines elements of both problem-driven and solution-driven design can often yield the most effective and user-centered outcomes.** This involves starting with a clear understanding of the problem, exploring multiple solution ideas, and refining the chosen solution based on user feedback and validation.

Problem-Driven Design

Focus: This approach centers around identifying and understanding the problem or need that the product aims to address.

Process

1. **Research and Analysis:** Conduct thorough research to identify user needs, pain points, and challenges related to the problem.
2. **Problem Definition:** Clearly define the problem statement, including user requirements, constraints, and objectives.
3. **Ideation:** Brainstorm potential solutions based on the identified problem and user insights.
4. **Prototyping and Testing:** Develop prototypes to validate and iterate on potential solutions based on user feedback.
5. **Iterative Refinement:** Continuously refine and improve the design based on iterative testing and feedback loops.

Benefits

1. Ensures that the product directly addresses a specific user need or problem.
2. Increases the likelihood of creating a valuable and meaningful solution for users.
3. Guides the design process by focusing efforts on solving a well-defined problem.

Solution-Driven Design

Focus: This approach starts with a predefined solution idea or concept and works towards refining and optimizing that solution.

Process

1. **Concept Development:** Begin with an initial solution idea or concept based on assumptions or previous knowledge.
2. **Prototyping and Validation:** Create prototypes to validate the feasibility and effectiveness of the proposed solution.
3. **Feedback Incorporation:** Gather user feedback and iterate on the solution to address usability issues or improvements.
4. **Refinement and Optimization:** Continuously refine and optimize the design based on feedback and testing results.

Benefits

1. Allows for rapid iteration and development of a specific solution concept.
2. Can be effective for improving existing products or features based on known user needs.
3. Provides clarity and focus by working towards enhancing a predetermined solution idea.

Design Thinking, Lean & Agile

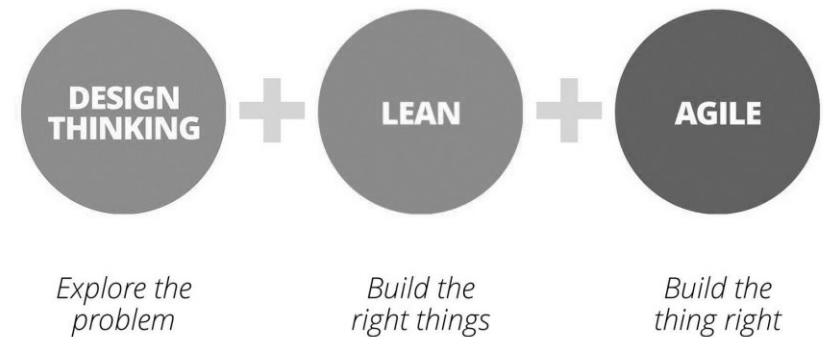
Developing a Personal Micro mobility EV Device within 5 months using Design Thinking, Lean, and Agile methodologies provides a structured yet flexible approach to creating a user-centered, efficient, and adaptive product.

Design Thinking serves as the foundation of the project, ensuring that the device meets real user needs. The process begins with deep user research to empathize with potential users, understanding their pain points and mobility challenges. Insights gathered help define the problem clearly, focusing on how the EV device can address specific needs like ease of use, portability, and safety. The ideation phase involves brainstorming innovative solutions, leading to the development of multiple concepts. Prototyping quickly follows, where rough versions of the device are created and tested with users to gather feedback. This iterative process ensures that the final design is both functional and user-friendly, aligning with the end-user's expectations.

Lean principles guide the development process by focusing on value creation and waste elimination. During the 5-month timeline, Lean emphasizes efficient use of resources, ensuring that every step in the design and production process adds value. The team continuously evaluates the design to eliminate unnecessary features that do not contribute to the core functionality, thereby reducing costs and speeding up development. Lean also promotes rapid prototyping and testing, enabling quick learning and iterative improvements. By maintaining a focus on what truly matters to the user, the development team can streamline the process and deliver a high-quality product within the tight timeframe.

Agile methodology is essential for managing the project within the 5-month period, offering flexibility and adaptability in response to challenges or changes in user needs. The project is broken down into short sprints, each focusing on specific aspects of the device such as battery technology, user interface, or material selection. Regular sprint reviews and retrospectives allow the team to assess progress, incorporate feedback, and pivot when necessary. Agile's emphasis on collaboration and communication ensures that all team members are aligned and can quickly respond to any issues that arise. This approach not only accelerates the development process but also ensures that the final product is well-refined and ready for market.

By **integrating Design Thinking, Lean, and Agile**, the development of a Personal Micro mobility EV Device within 5 months becomes a well-coordinated effort. Design Thinking ensures the product is desirable, Lean ensures it is viable and efficient to produce, and Agile ensures it can be developed quickly and adaptively. Together, these methodologies maximize the likelihood of delivering a successful and user-centered micro mobility solution within a constrained timeline.



Agile Methodology

Agile Methodology is an ideal approach for developing a Personal Micromobility EV Device within a tight 5-month timeline, as it emphasizes flexibility, iterative progress, and continuous improvement. Here's how Agile can be effectively applied to this project:

1. Sprint Planning and Task Breakdown:

Begin by outlining the project's goals and breaking down the work into manageable tasks or "user stories" that can be completed in short iterations, or sprints. Each sprint should focus on developing and testing a specific feature, such as motor integration, battery management, or user interface design. Planning your sprints helps you stay organized and ensures steady progress toward your goals.

2. Prioritization and Flexibility:

You need to determine which features are essential for the MVP (Minimum Viable Product) and which can be refined or added later. Agile's inherent flexibility allows you to adapt as you progress, so if you encounter a challenge or discover a new user need, you can re-prioritize tasks to address it effectively.

3. Iterative Development:

Agile's iterative approach means that you'll continuously build and refine your product. After each sprint, you'll test what you've developed to ensure it meets your goals and gather feedback—whether from potential users, advisors, or your own critical review. This process helps you identify and fix issues early, improving the product with each iteration.

4. Continuous Feedback:

Even without a team, feedback is essential. You can seek input from mentors, potential users, or industry peers to validate your progress. Regularly integrating this feedback into your development cycle helps ensure the product meets real-world needs and is on track for success.

5. Retrospective and Self-Improvement:

After each sprint, take time to reflect on what went well and what didn't. This self-assessment is crucial for improving your efficiency and adjusting your approach as needed. Agile encourages learning from each cycle, so use retrospectives to fine-tune your process, whether it's adjusting your timeline, refining your task breakdown, or improving your prototyping methods.

6. Documentation and Organization:

While Agile emphasizes working products over documentation, as a solo developer, it's important to maintain key records. Document your progress, decisions, and any changes to your plan. This ensures that you have a clear roadmap and can easily pick up where you left off after any interruptions.

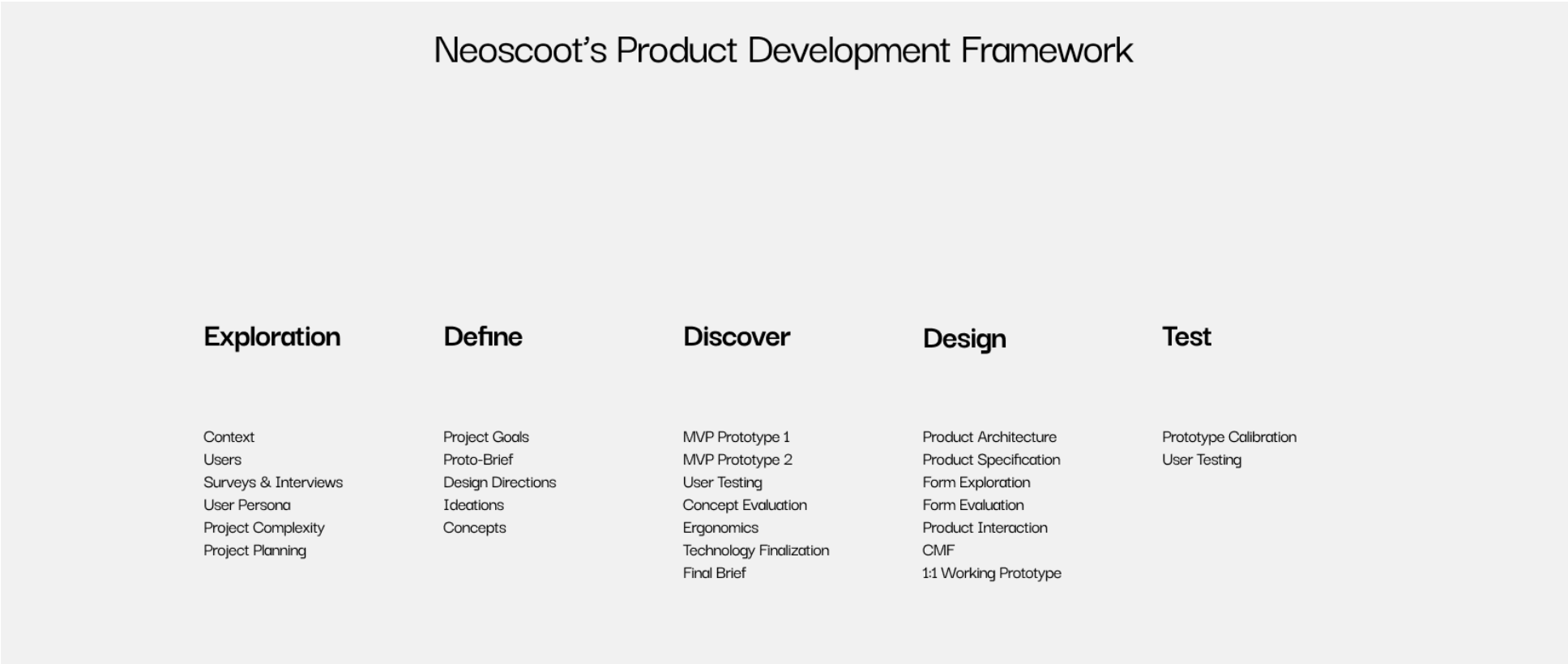
7. Delivery and Final Testing:

As you approach the project's completion, the iterative nature of Agile ensures that you'll have a well-tested, refined product ready for final testing and potential deployment. You can gradually increase the scope of testing, from initial prototypes to the final version, ensuring each aspect of the device meets your standards and user expectations.

By adapting Agile methodology to the workflow, we can manage the development of a Personal Micro mobility EV Device effectively within 5 months. Agile's focus on iteration, flexibility, and continuous improvement will help you stay organized, adapt to challenges, and ultimately deliver a high-quality product.

Rapid Agile Development Framework

Considering the time scope of P3 project (5 Months) and the Complexity level of designing an EV a rapid and agile workflow is to be adapted. This framework integrates agile methodologies with a thorough understanding of business, marketing, and product launch strategies, ensuring that products are developed rapidly while maintaining high quality and market relevance.



MARKET STUDY

06

Why Micro-Mobility and EV?

Micromobility EVs refer to small, lightweight electric vehicles designed for short-distance travel, typically in urban environments. These vehicles include e-scooters, e-bikes, electric skateboards, and even compact personal transport devices like electric Segways. The rise of micromobility EVs represents a shift in urban transportation, driven by the need for sustainable, efficient, and accessible mobility solutions.

Key Characteristics of Micromobility EVs

Compact Size: Micromobility EVs are designed to be small and easy to maneuver, making them ideal for congested urban areas. Their compact size allows for easier storage and parking, often in places where traditional vehicles cannot go.

Electric Power: These vehicles are powered by electric motors, which provide a clean and quiet alternative to internal combustion engines. The use of electric power aligns with global efforts to reduce carbon emissions and combat climate change.

Short-Distance Travel: Micromobility EVs are optimized for trips typically ranging from 1 to 10 miles. They are often used for commuting, running errands, or connecting with other forms of public transportation, effectively addressing the "last mile" problem.

Accessibility and Affordability: Many micromobility EVs are available through shared services, making them accessible without the need for ownership. The cost of using these services is generally lower than traditional transportation options, making them an affordable choice for many users.

Advantages of Micromobility EVs

Environmental Benefits: With zero tailpipe emissions, micromobility EVs contribute to cleaner air in cities. They also help reduce the carbon footprint of urban transportation when charged with renewable energy sources.

Reduced Traffic Congestion: As more people opt for micromobility options, the number of cars on the road can decrease, leading to less traffic congestion and shorter travel times in dense urban areas.

Efficiency and Convenience: Micromobility EVs provide quick and efficient transportation for short trips, often offering a door-to-door solution that public transportation or cars cannot match. Their ability to bypass traffic jams and park easily makes them highly convenient.

Health and Wellness: Some micromobility options, like electric bikes, encourage physical activity, which can have positive health benefits. Even motorized options contribute to a more active lifestyle by integrating with other forms of transport that may require walking.

Economic Opportunities: The micromobility sector has created new business models, such as shared mobility services, which have spurred economic growth and innovation in the transportation industry.

Challenges and Considerations

Infrastructure: The widespread adoption of micromobility EVs requires appropriate infrastructure, such as dedicated bike lanes, charging stations, and parking spaces. Cities need to adapt to support this new mode of transportation.

Safety: Safety concerns, including accidents involving pedestrians and other vehicles, are a significant challenge. Ensuring that riders follow traffic rules and wear protective gear is essential.

Regulation: As micromobility EVs become more popular, there is a growing need for clear regulations that balance innovation with public safety. This includes guidelines for vehicle standards, operation areas, and user behavior.

Battery and Environmental Impact: While electric power is cleaner than fossil fuels, the production and disposal of batteries pose environmental challenges. Advances in battery technology and recycling processes are crucial to minimizing the environmental impact of micromobility EVs.

The Future of Micromobility EVs

The future of micromobility EVs looks promising, with continued innovation expected in vehicle design, battery efficiency, and smart technology integration. As cities around the world seek to reduce their carbon footprints and improve urban livability, micromobility EVs will likely play a central role in shaping the future of transportation. Governments, businesses, and urban planners must collaborate to ensure that these vehicles are safely and efficiently integrated into the existing transportation ecosystem.

Market of Micro-Commute

The personal micro-mobility market is dynamic and evolving, driven by urbanization, sustainability goals, and technological innovation. Understanding market trends, consumer preferences, regulatory landscapes, and technological advancements is essential for stakeholders seeking to capitalize on the opportunities in this rapidly growing sector.

A detailed market study of personal micro-mobility devices involves analyzing various factors including market trends, key players, consumer preferences, technological advancements, regulatory considerations, and market segmentation.

Market Trends and Growth Drivers

Rise of Urbanization: Increasing urbanization and congestion in cities are driving demand for compact and efficient transportation solutions.

Shift Towards Sustainability: Growing awareness of environmental issues and the need for eco-friendly transportation options are boosting the adoption of electric micro-mobility devices.

Last-Mile Connectivity: The need to bridge gaps between public transit stations and final destinations is fueling demand for portable and convenient micro-mobility solutions.

Key Players and Competitive Landscape

Startups and Established Brands: Companies like Lime, Bird, Segway-Ninebot, and Xiaomi dominate the market with electric scooters and bikes.

Diversification of Offerings: Established players in the traditional bicycle and automotive industries are entering the micro-mobility space, diversifying the market.

Consumer Preferences and Demographics

Millennials and Gen Z: Younger generations prefer sustainable and tech-savvy mobility solutions that align with their urban lifestyles.

Convenience and Affordability: Consumers prioritize convenience, affordability, and ease of use when choosing micro-mobility devices.

Technological Advancements

Battery Technology: Advancements in battery technology, including lithium-ion batteries, have enabled longer ranges and faster charging times for electric devices.

Connected Mobility: Integration of smart features such as GPS tracking, app connectivity, and IoT capabilities enhances user experience and operational efficiency.

Regulatory Environment

Regulation of Micro-mobility: Cities and municipalities are implementing regulations and permitting processes to manage the deployment and operation of micro-mobility services.

Safety and Infrastructure: Safety regulations, including speed limits and helmet requirements, impact device design and user behavior.

Market Segmentation

Device Types: Segmentation based on device types such as electric scooters, bikes, skateboards, and unicycles.

Use Cases: Segmentation based on use cases including commuting, leisure, and mobility assistance for individuals with disabilities.

Geographical Segmentation: Market dynamics and adoption rates vary across regions due to factors like infrastructure, culture, and regulatory frameworks.

Challenges and Opportunities

Infrastructure Limitations: Insufficient infrastructure, including bike lanes and charging stations, poses challenges for widespread adoption.

Data Privacy and Security: Managing user data and ensuring cybersecurity are critical considerations for micro-mobility operators.

Partnerships and Collaborations: Opportunities exist for partnerships between micro-mobility providers, public transit agencies, and urban planners to optimize transportation networks.

E Micro-Mobility Products

01



E-Bikes

E-bikes combine traditional bicycle designs with electric motor assistance, offering a versatile and eco-friendly transportation option. They provide pedal-assist or full electric modes for varying levels of exertion and speed.

02



E-Scooters

E Scooters are compact and lightweight electric vehicles designed for short urban commutes. They feature handlebars and a deck, making them easy to ride and store. E Scooters are popular for their convenience and portability.

03



Segway

Segway is a self-balancing personal transporter equipped with gyroscopic sensors. Riders control them by shifting their weight, allowing for intuitive and stable movement. Segways are known for their futuristic design and ease of use.

04



Hoverboards

Hoverboards are self-balancing scooters with two wheels, ridden similarly to Segway but without handlebars. They are compact and maneuverable, offering a unique and agile riding experience.

05



E-Skateboards

Motorized skateboards equipped with electric motors and rechargeable batteries, offering a thrilling and exhilarating mode of transportation for riders seeking speed and agility. They provide a dynamic and sporty way to commute and explore urban environments.

06



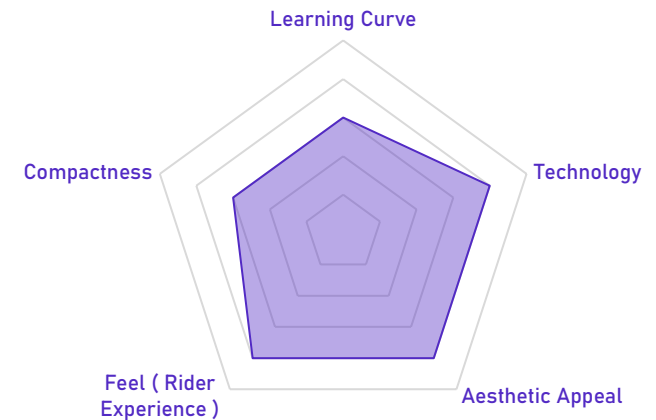
Uni-wheel

Uni-wheel vehicles feature a single wheel and electric motor, requiring riders to balance actively. They are compact and nimble, ideal for urban environments but with a steeper learning curve.

E-Bikes/E-Bicycle

justification

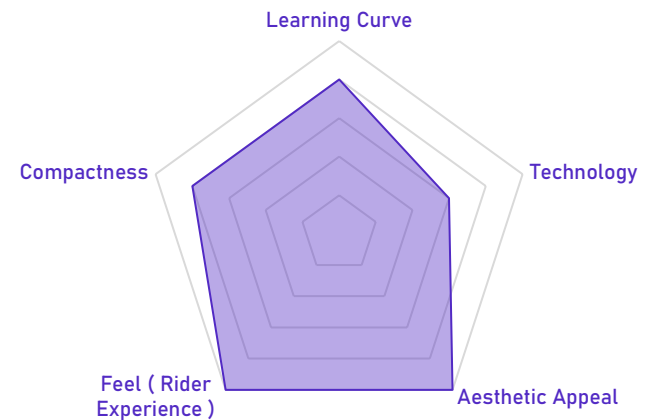
1. **Learning Curve (3/5):** The learning curve for an e-bike is moderate. While the basic operation of an e-bike is relatively straightforward—primarily involving pedaling with motor assistance—users still need to become familiar with additional features such as varying levels of pedal assist, battery management, and different riding modes. New users might require a brief period of adjustment to fully utilize all functionalities and optimize their riding experience.
2. **Technology (4/5):** E-bikes employ advanced technology, including electric motors, batteries, and sophisticated control systems. This high-tech integration supports smooth and efficient riding experiences. However, there is still room for improvement in terms of battery life, motor efficiency, and integration with smart technology. Overall, the technology used in e-bikes is impressive but not without its areas for advancement.
3. **Aesthetic Appeal (4/5):** Many e-bikes have a sleek, modern design that appeals to contemporary tastes. Manufacturers often invest in stylish frames and finishes, making them visually attractive. However, as the market grows, there is a wider range of designs, from traditional to futuristic, and some e-bikes may not yet reach the aesthetic standards of luxury or high-end bicycles.
4. **Feel (Rider Experience) (4/5):** The riding experience of an e-bike is generally positive, providing smooth acceleration, reduced effort on inclines, and overall comfort. The integration of the electric motor enhances the ride, making it easier and more enjoyable. However, some riders may still experience issues like noise from the motor or the additional weight of the battery, which can slightly affect the overall feel.
5. **Compactness (3/5):** E-bikes tend to be bulkier than traditional bicycles due to the inclusion of the motor and battery. While there are efforts to design more compact models, the essential components of an e-bike still contribute to its larger size. This can impact storage and portability, making them less convenient for those who need a highly compact or easily transportable vehicle.



E-Scooter

justification

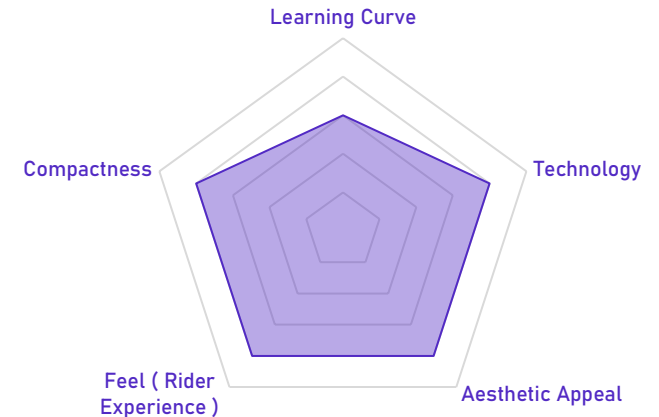
1. **Learning Curve (4/5):** E-scooters generally have a relatively low learning curve. Most users can quickly grasp the basic controls, such as accelerating, braking, and steering. However, mastering maneuvering and handling, especially in different environments or at higher speeds, might require some practice. Overall, the learning process is straightforward but may involve a brief adjustment period for optimal use.
2. **Technology (3/5):** E-scooters incorporate technology such as electric motors, batteries, and electronic control systems. However, compared to more advanced electric vehicles, the technology in e-scooters is simpler and often less sophisticated. Issues like limited battery life, basic control systems, and varying motor efficiency contribute to a more average score. While functional, there is room for improvement in terms of technological innovation.
3. **Aesthetic Appeal (5/5):** E-scooters often excel in aesthetic appeal with their sleek, modern designs and vibrant color options. Manufacturers frequently focus on creating visually striking and stylish models that attract attention. The design of many e-scooters aligns well with contemporary trends, making them highly appealing in terms of looks.
4. **Feel (Rider Experience) (5/5):** The rider experience on an e-scooter is typically excellent, offering smooth and enjoyable rides. E-scooters provide a comfortable and responsive ride with easy maneuverability. Their intuitive controls and the thrill of riding contribute to a highly satisfying experience. The balance and handling are well-tuned, making the riding feel both fun and efficient.
5. **Compactness (4/5):** E-scooters are relatively compact compared to other electric vehicles, making them convenient for urban commuting and storage. Their foldable designs and lightweight build contribute to their portability. However, the battery and motor components still add some bulk, so while they are compact, they are not as easily storable as smaller personal items.



Segway

justification

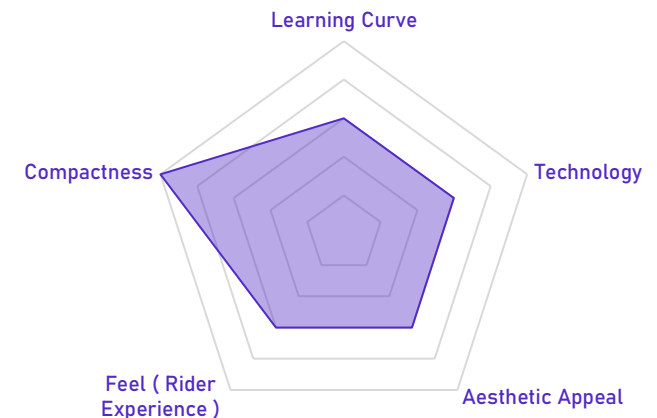
1. **Learning Curve (3/5):** Segways have a moderate learning curve. While they offer a unique and intuitive balancing mechanism, new users may need some time to get accustomed to the controls and balance. The process involves learning to adjust body movements and handle the device smoothly, which can take a bit of practice. Once mastered, however, riding a Segway becomes relatively easy.
2. **Technology (4/5):** Segways feature advanced technology, including gyroscopic sensors, electric motors, and sophisticated balance control systems. These components work together to provide a stable and responsive ride. While the technology is impressive and effective, there is always potential for further refinement and innovation to enhance performance and efficiency.
3. **Aesthetic Appeal (4/5):** Segways generally have a modern and futuristic design that appeals to many users. Their sleek, minimalistic look and innovative appearance contribute to their aesthetic appeal. However, design preferences can vary, and while many find Segways visually attractive, others may view them as unconventional or less stylish compared to more traditional or streamlined options.
4. **Feel (Rider Experience) (4/5):** The rider experience on a Segway is typically smooth and enjoyable. The device provides a stable ride with responsive handling and minimal effort required for movement. Users often appreciate the ease of maneuverability and the sensation of gliding. However, some may find the learning curve or initial adjustment period slightly disruptive to the overall experience.
5. **Compactness (4/5):** Segways are relatively compact for their functionality. They are designed to be portable and easy to store, with a footprint that is smaller than many other personal transport devices. However, they are still bulkier compared to some alternatives, like foldable e-scooters, due to their structural components and balance mechanisms. Despite this, they are more compact than many other transportation options.



Hoverboard

justification

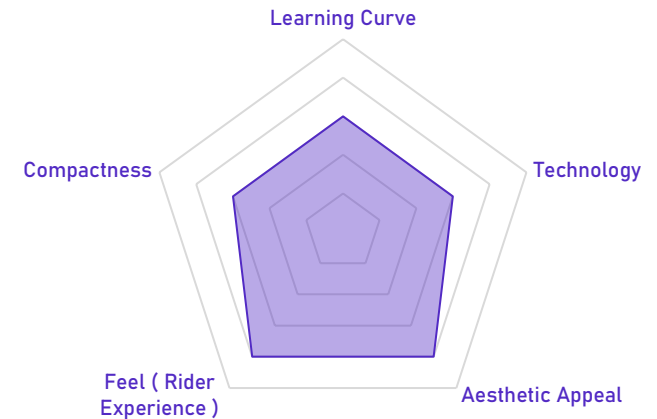
1. **Learning Curve (3/5):** Hoverboards have a moderate learning curve. Balancing on a hoverboard requires some initial practice as users need to get used to the sensitivity of the controls and the need to adjust their body weight to maintain stability. While the basic operation becomes easier with time, mastering smooth movement and navigating obstacles can still present challenges.
2. **Technology (3/5):** Hoverboards use basic technology, including gyroscopic sensors and electric motors, but are less advanced compared to more sophisticated personal transport devices. The technology supports basic balancing and propulsion functions but can be limited in terms of battery life, speed, and overall performance. There is room for improvement in the technology to enhance efficiency and reliability.
3. **Aesthetic Appeal (3/5):** The aesthetic appeal of hoverboards is average. They are designed with a functional and often utilitarian look, which may not stand out in terms of style. While there are various colors and designs available, they generally have a bulkier appearance compared to more sleek or modern alternatives, making their visual appeal somewhat basic.
4. **Feel (Rider Experience) (3/5):** The rider experience on a hoverboard is average. While they offer a fun and novel way to get around, the ride can be less smooth compared to other options. The experience can be influenced by factors such as the quality of the hoverboard's components and the rider's ability to balance. Some users might find the ride bumpy or less comfortable over uneven surfaces.
5. **Compactness (5/5):** Hoverboards excel in compactness. They are designed to be small, lightweight, and easy to carry, making them highly portable. Their compact design allows for convenient storage and transport, especially in urban environments. The small footprint of hoverboards makes them an excellent choice for those who need a space-efficient mode of personal transport.



E-Skateboard

justification

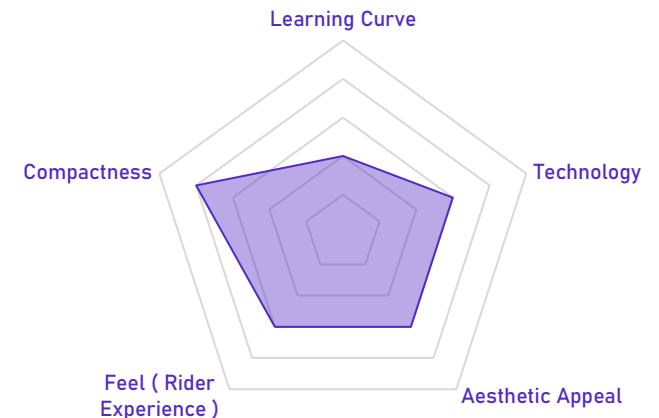
1. **Learning Curve (3/5):** E-skateboards have a moderate learning curve. While riding an e-skateboard involves similar balance and movement skills as traditional skateboarding, users need to become familiar with the additional control mechanisms like remote controls or throttle systems. Adjusting to the speed and handling of the e-skateboard might take some time, especially for beginners.
2. **Technology (3/5):** E-skateboards feature basic technology, including electric motors, batteries, and control systems. While functional, the technology is relatively simple compared to more advanced personal transportation devices. Issues like limited battery life, motor efficiency, and basic control interfaces contribute to an average rating. There is potential for improvement in performance and technological sophistication.
3. **Aesthetic Appeal (4/5):** E-skateboards often have a stylish and modern design, which can be visually appealing. Many models feature sleek lines, custom graphics, and a variety of color options. The design often reflects contemporary trends, making them attractive to those who appreciate both functionality and style. However, aesthetics can vary based on brand and model.
4. **Feel (Rider Experience) (4/5):** The rider experience on an e-skateboard is generally positive. E-skateboards provide a thrilling and enjoyable ride with smooth acceleration and the ability to cover distances efficiently. The experience can be influenced by factors such as board quality, motor performance, and terrain. Overall, the ride is usually fun and engaging, with some variability based on individual preferences and conditions.
5. **Compactness (3/5):** E-skateboards are moderately compact. They are more portable than some other personal transportation devices but can be bulkier than traditional skateboards due to the inclusion of batteries and motors. While they are designed to be relatively easy to carry and store, they are not as compact or lightweight as some alternatives, which may impact their portability and convenience.



E- Unicycle

justification

1. **Learning Curve (2/5):** E-unicycles have a steep learning curve. Balancing on a single wheel requires significant practice and skill, as users must learn to adjust their body weight and control the device without the support of additional wheels. Mastery of the e-unicycle involves overcoming challenges related to balance, steering, and speed control, which can be difficult for beginners.
2. **Technology (3/5):** E-unicycles feature basic technology, including a motor, battery, and gyroscopic sensors to maintain balance. While functional, the technology is relatively straightforward and lacks the advanced features seen in other personal transport devices. Issues such as limited battery life and basic control mechanisms contribute to an average rating. There is potential for further technological innovation to improve performance and user experience.
3. **Aesthetic Appeal (3/5):** The aesthetic appeal of e-unicycles is average. They are designed with a functional look that prioritizes utility over style. While some models have sleek and modern designs, they generally lack the distinctive or eye-catching appearance found in more aesthetically focused personal transportation devices. The design is practical but not particularly standout.
4. **Feel (Rider Experience) (3/5):** The rider experience on an e-unicycle is average. While it offers a unique and engaging ride, it can be challenging due to the need for precise balance and control. The ride quality can vary depending on the model and riding conditions, and users may find it less comfortable or intuitive compared to more stable or familiar modes of transport.
5. **Compactness (4/5):** E-unicycles are relatively compact and portable. Their single-wheel design allows for a small footprint, making them easy to carry and store. This compactness is a significant advantage in urban environments where space is limited. However, while they are more compact than many other personal transport devices, their design still includes essential components like the motor and battery, which can add some bulk.

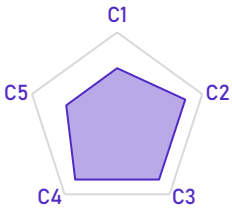


Product Benchmarking

01



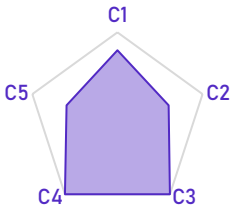
E-Bikes



02



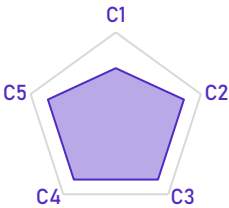
E-Scooters



03



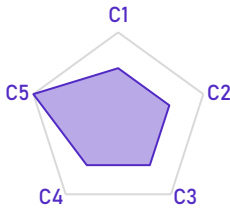
Segway



04



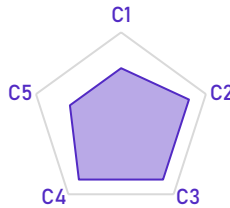
Hoverboards



05



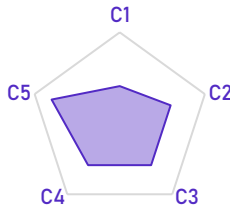
E-Skateboards



06



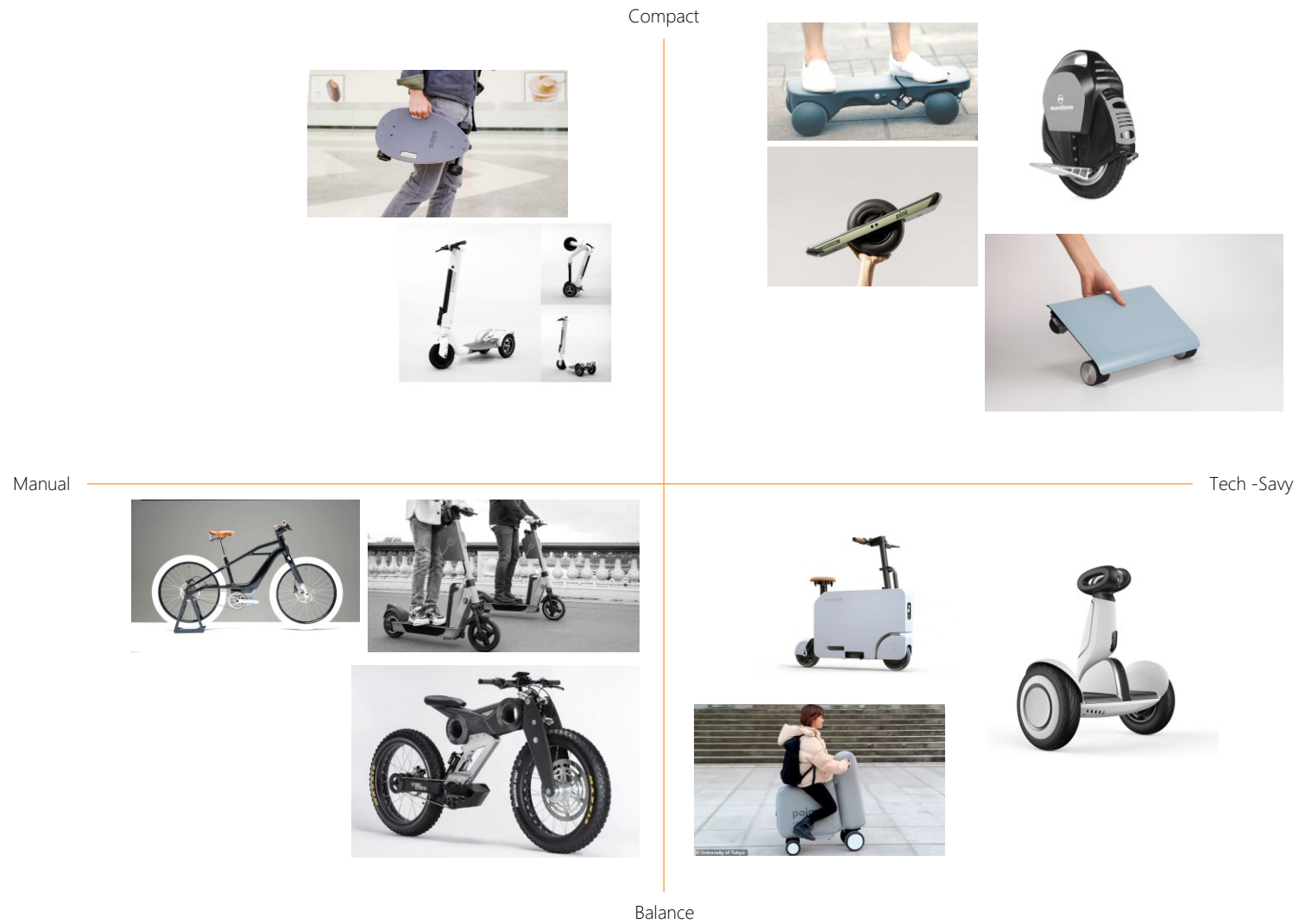
Uni-wheel



OPPERTUNITY

07

Trend Chart



Design Proto-Brief

“

A personal mobility solution that is affordable compared to other modes of transport, weather responsive as that can be used in rains, effortless while riding, compact and that falls around price range of 15000-17000 Rs with features like Motor Assistance, Bag and Laptop Carriage, Speed Controls etc.

”

DESIGN DIRECTIONS

08

Direction A

The system design for personal transportation aims to deliver agility, ease of use, affordability, and convenience by introducing a network of stations where users can access the devices. These stations serve as hubs strategically located across the area of operation, providing a seamless experience for users to pick up and drop off their transportation devices.

Each personal transportation device is designed to be agile, allowing users to navigate through urban environments with ease. The user experience is crafted to be effortless, with intuitive controls and ergonomic design ensuring comfort during the commute.

Affordability is a key consideration, with the system offering cost-effective options for users to access the transportation devices. By utilizing a station-based model, the system optimizes resource allocation and operational efficiency, thereby minimizing costs for both users and operators.

Overall, the system design prioritizes user-centricity and accessibility, aiming to revolutionize urban mobility by offering a convenient, agile, and affordable solution for personal transportation.



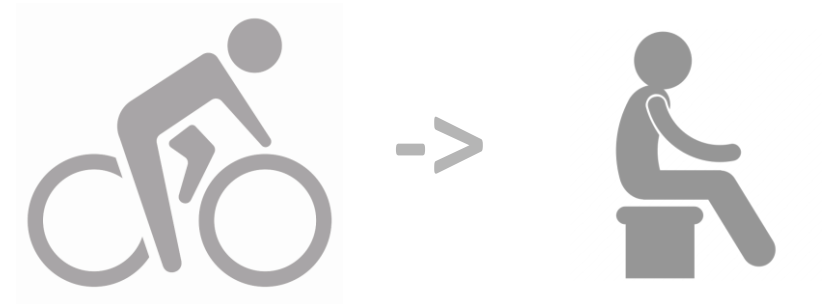
Direction B

The concept of a personal transportation device with multifunctional capabilities aims to redefine urban mobility for students, offering agility, ease of use, and affordability. This innovative device not only serves as a means of transportation but also transforms into functional furniture, seamlessly integrating into the user's living space or communal areas.

Designed with agility in mind, the device enables students to navigate crowded campuses and urban environments with ease, making commuting effortless and efficient. Its compact and lightweight design ensures portability, allowing users to carry it around and store it in their rooms when not in use.

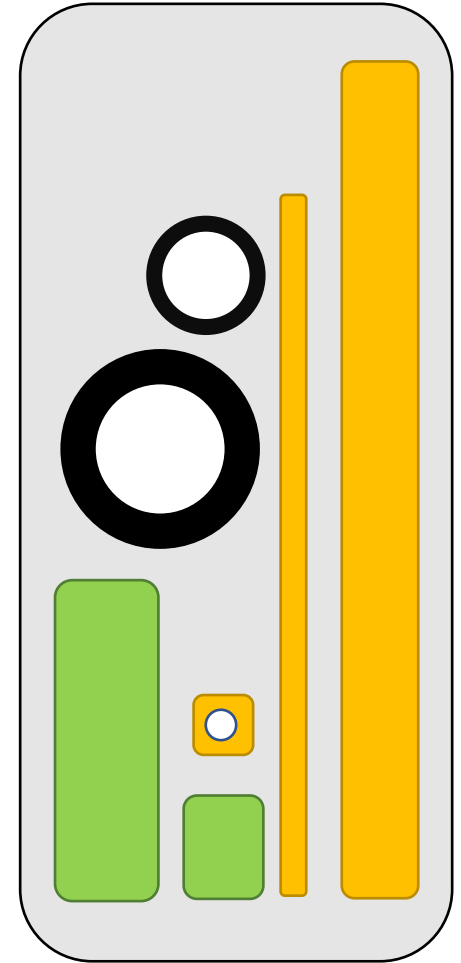
The device's transformative feature sets it apart by offering additional utility beyond transportation. When not being ridden, it can be effortlessly converted into a chair or table, providing students with a convenient and space-saving solution for their living and study areas. Additionally, it can integrate with existing street furniture as part of the parking infrastructure, optimizing space utilization and enhancing the campus environment.

By combining functionality, portability, and affordability, this personal transportation device addresses the diverse needs of students, offering a versatile solution that enhances both mobility and living spaces.



Direction C

This system proposes a personal transportation solution designed for easy disposal and reusability after the academic period. It features a modular design using recyclable materials, allowing students to assemble and customize their vehicles with a do-it-yourself (DIY) approach. At the end of the academic period, components can be dismantled and refurbished for future use, promoting sustainability and cost-efficiency. This approach fosters creativity, hands-on learning, and environmental responsibility while providing students with affordable transportation options tailored to their needs.



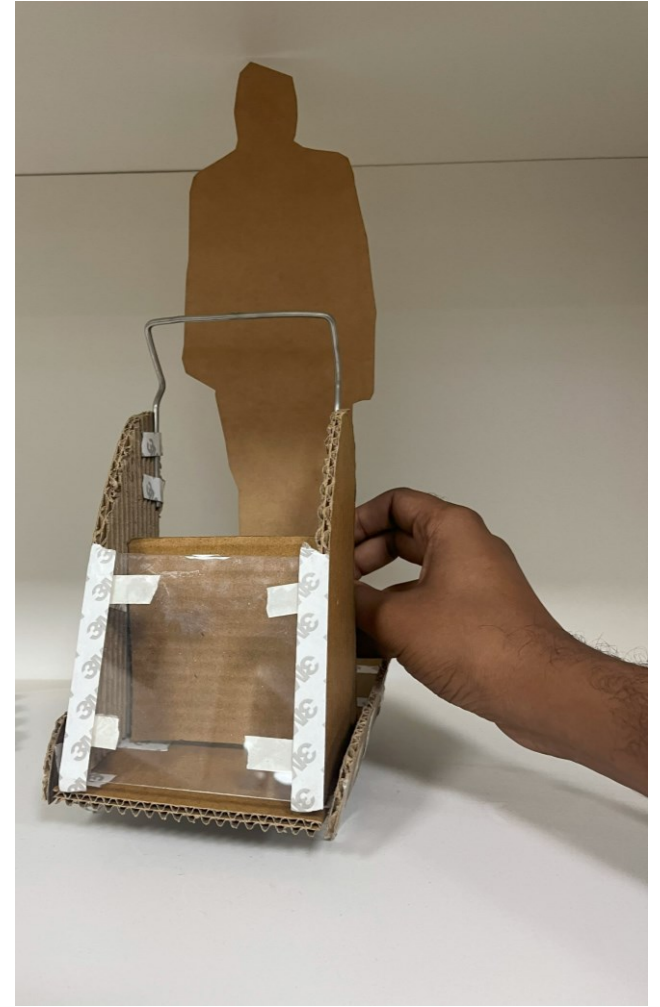
Final Design Direction

The refined design direction is to craft a compact and futuristic personal mobility device, emphasizing aspects such as interaction design, advanced technology integration, sleek form factor, aesthetic appeal, and premium materials. The device should be user-owned and easily portable, enabling users to carry it into various spaces and conveniently charge it when needed.

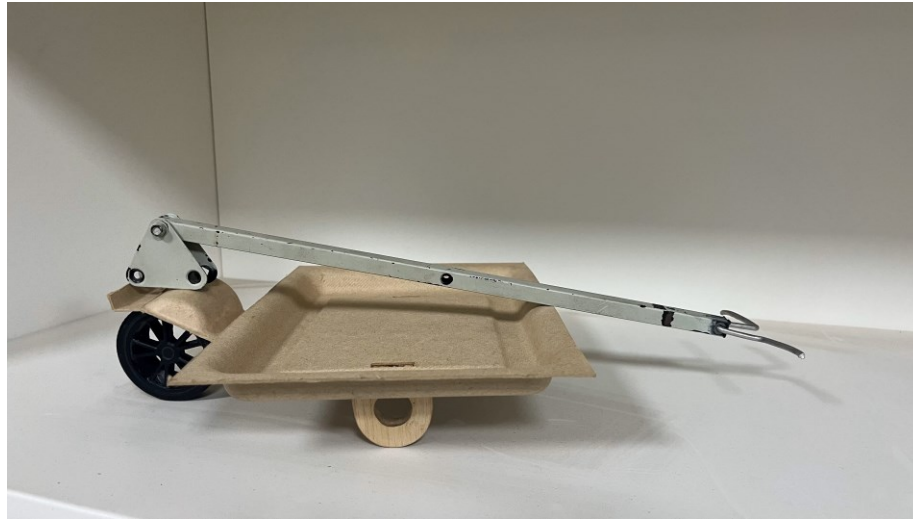
IDEATIONS

09

Ideation 1



Ideation 2



TECHNOLOGY EXPLORATION

10

Wheel Configuration

The selection of wheel number and layout in a personal micro mobility device involves a balance of stability, maneuverability, comfort, and practicality based on user needs and environmental factors. We must carefully evaluate these factors to create a safe, efficient, and enjoyable mobility solution tailored to specific use cases and preferences.

Factors for Selecting the Number of Wheels

Stability

More wheels generally provide better stability, especially when stationary or at low speeds. Three or four-wheel configurations are common choices for enhanced stability, compared to two-wheel designs that require active balance control.

Maneuverability

Fewer wheels can improve maneuverability, allowing for tighter turns and agility. Two-wheel designs (such as bicycles or scooters) are highly maneuverable for navigating through narrow spaces and urban environments.

Weight and Size

More wheels can add weight and complexity to the device, affecting portability and ease of use. Lightweight devices often prioritize fewer wheels for easier carrying and storage.

Ride Comfort

Additional wheels can provide a smoother ride by distributing the rider's weight more evenly. (Traction – Points of contact with the ground). Suspension systems and wheel size/material also impact ride comfort.

Factors for Selecting the Layout of Wheels

Wheel Placement

Front-Wheel Drive (FWD), Rear-Wheel Drive (RWD), or All-Wheel Drive (AWD) configurations impact traction and handling. Front-wheel layouts are common for stability and simplicity, while rear-wheel layouts offer better traction for acceleration.

Wheel Size and Type

Larger wheels offer better stability and comfort over uneven terrain. Pneumatic (air-filled) tires provide shock absorption and grip, suitable for varied surfaces.

Wheel Arrangement:

Parallel or inline wheel arrangements affect stability and turning radius. Triangular or diamond configurations distribute weight and balance.

Specialized Requirements:

Considering specific needs such as off-road capability, urban commuting, or indoor maneuvering. Adaptive wheel layouts for different terrains (e.g., climbing stairs, navigating curbs).



Wheel Numbers

When designing a vehicle, whether it's a car, motorcycle, or personal mobility device, the number of wheels is a critical design choice that impacts maneuverability, traction, stability, and overall performance.

Maneuverability

Tight Turns

Vehicles with fewer wheels, such as motorcycles or bicycles, tend to have better maneuverability for making tight turns and navigating through narrow spaces. A narrower wheelbase and smaller turning radius enable agile maneuvering in urban environments or congested areas.

Low-Speed Handling

Three-wheeled vehicles, like trikes or three-wheeled scooters, often offer enhanced low-speed stability and maneuverability compared to traditional four-wheeled vehicles. Triangular wheel configurations distribute weight optimally for controlled handling at lower speeds.

Agility

Two-wheeled vehicles, including bicycles and scooters, provide high agility for quick lane changes, weaving through traffic, and navigating obstacles. Riders can lean into turns to adjust the vehicle's trajectory, enhancing responsiveness and agility.

Traction

Surface Contact

The number and arrangement of wheels impact the amount of surface contact and traction with the road or terrain. Vehicles with more wheels distribute weight more evenly, increasing traction and stability, especially on slippery surfaces.

Off-Road Capability

Multi-wheeled vehicles, like ATVs (All-Terrain Vehicles) or off-road trucks, utilize multiple driven wheels to enhance traction and climb over rough terrain. Six or eight-wheel configurations improve off-road capability by spreading the vehicle's weight across a larger surface area.

Stability and Control

Balance and Stability

Additional wheels contribute to greater overall stability, especially at higher speeds or during sudden maneuvers. Four-wheeled vehicles, like cars and trucks, benefit from a balanced weight distribution among multiple wheels, enhancing stability on highways and winding roads.

Braking and Cornering

The layout of wheels affects braking performance and cornering stability. Vehicles with a well-balanced wheel arrangement can maintain control during emergency braking and sharp turns, minimizing the risk of skidding or loss of traction.



Four Wheel Configuration

When designing a vehicle, whether it's a car, truck, or a personal micro mobility device, the choice of wheel configuration—specifically, the number of wheels—affects crucial factors such as maneuverability, traction, stability, and overall performance. Let's explore why a four-wheel configuration is often preferred and how it impacts these key aspects:

Maneuverability

Tight Turns: Vehicles with four wheels typically have a better turning radius compared to vehicles with more wheels. This allows for easier maneuvering in confined spaces and urban environments.

Agility: Four-wheel configurations provide good agility, allowing the vehicle to navigate around obstacles and make quick directional changes.

Traction

Improved Grip: Each wheel in a four-wheel setup shares the load, distributing weight more evenly and providing better traction, especially on uneven or slippery surfaces.

Enhanced Stability: Four-wheel drive systems offer improved stability, especially during acceleration and cornering, by distributing power to multiple wheels.

Stability

Balanced Weight Distribution: With four points of contact with the ground, four-wheel vehicles typically exhibit better balance and stability, reducing the risk of rollovers or loss of control.

Controlled Handling: The distribution of weight across four wheels enhances vehicle control and responsiveness, contributing to safer driving dynamics.

Why Four-Wheel Configuration Is Preferred

Versatility: Four-wheel vehicles strike a balance between maneuverability and stability, making them suitable for a wide range of applications, from daily commuting to off-road adventures.

All-Wheel Drive (AWD) Capability: Many four-wheel configurations offer all-wheel drive capabilities, which enhance traction and performance in challenging road conditions. **This catered to the usage of Dual Motor Electric Differential Technology.**

Consistent Performance: Four-wheel setups deliver predictable and consistent performance across various terrains and driving scenarios.

Industry Standard: In automotive design, the four-wheel configuration is a well-established and widely adopted layout, offering a proven balance of handling, stability, and efficiency.

In summary, the number of wheels in a vehicle design—specifically opting for a four-wheel configuration—plays a critical role in determining its maneuverability, traction, stability, and overall performance. The versatility and reliability of four-wheel setups make them a preferred choice for a wide range of vehicles, offering a harmonious blend of handling dynamics and driving comfort across diverse operating conditions.

By leveraging the benefits of a four-wheel layout, vehicle designers can optimize both functionality and safety, meeting the needs of drivers and users in various transportation contexts.



Three Wheel Configuration

When considering a personal mobility device for use on the IIT campus, the choice of wheel configuration is crucial. Let's explore why a three-wheel configuration might not be ideal for this environment: While three-wheel configurations may have certain advantages such as agility and compactness, they may not be optimal for the IIT campus environment due to concerns related to stability, fear of riding, and overall user experience. A four-wheel configuration would likely offer better stability, handling, and accessibility, catering to the diverse mobility needs of individuals navigating the campus on a daily basis.

Factors Against a Three-Wheel Configuration

Stability on Sloppy Roads

1. Three-wheel designs may have reduced stability, especially on uneven or sloppy roads commonly found on the IIT campus.
2. The presence of slopes and varying terrain could challenge the balance and control of a three-wheel vehicle, posing safety concerns for riders.

Fear of Riding:

1. Some riders may experience apprehension or fear when using a three-wheel vehicle, particularly on inclines or during maneuvers.
2. The perceived lack of stability compared to four-wheel designs could deter users from confidently navigating campus pathways.

Accessibility and User Experience:

1. A three-wheel configuration, while potentially offering agility, may not accommodate all users, particularly those less experienced with riding or who prefer a more stable platform.
2. Accessibility and ease of use are essential factors in a campus setting where diverse users with varying skill levels and mobility needs coexist.

Handling and Maneuverability:

1. Three-wheel layouts may have limitations in terms of handling and

- maneuverability, especially in tight spaces or when making sharp turns.
2. The design's agility could be offset by challenges in stability and control, impacting the overall usability in a campus environment.

Considerations for IIT Campus Environment

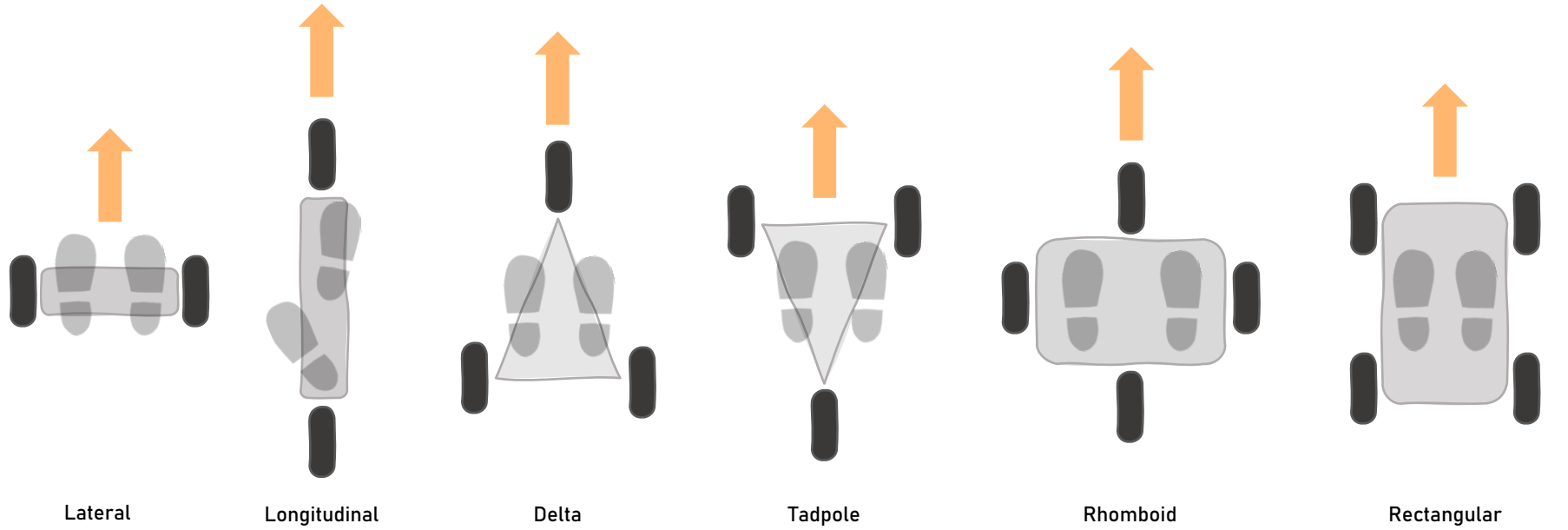
Varied Terrain: The IIT campus features diverse terrain, including slopes, pathways, and potentially congested areas.

User Diversity: Students, faculty, and staff of varying ages and skill levels navigate the campus daily, necessitating a mobility solution that prioritizes safety, accessibility, and comfort.

Stability and Confidence: A four-wheel configuration generally offers better stability and confidence-inspiring handling, making it a more suitable choice for a wide range of users.



Wheel Configurations



Powering Motion : Batteries

Lithium iron phosphate (LiFePO₄) batteries are a type of lithium-ion battery known for their high energy density, long cycle life, and improved safety characteristics compared to other lithium-ion chemistries. Here's an overview of LiFePO₄ batteries and their properties, focusing on a specific configuration of 12V 12000mAh:

Chemistry and Composition

LiFePO₄ batteries use lithium iron phosphate as the cathode material, which is combined with a graphite anode and an electrolyte solution. The specific chemical composition includes lithium (Li), iron (Fe), phosphate (PO₄), and other materials that contribute to the battery's performance.

Voltage and Capacity

The specified configuration of 12V 12000mAh indicates the battery's nominal voltage (12V) and its capacity (12000mAh or 12Ah). LiFePO₄ batteries typically have a nominal voltage of 3.2V per cell, so a 12V battery pack would consist of multiple cells connected in series.

Properties and Advantages

Safety: LiFePO₄ chemistry is considered safer than other lithium-ion chemistries like lithium cobalt oxide (LiCoO₂) due to its higher thermal and chemical stability, reducing the risk of thermal runaway or fire. LiFePO₄ cells are much more stable chemically and non combustible. At high temperatures or if the battery is mishandled the phosphate based cathode material will not burn. Hence LiFePO₄ are much more safe for E-Vehicles and mobile robots

Long Cycle Life: LiFePO₄ batteries can endure a higher number of charge-discharge cycles compared to other lithium-ion batteries, making them suitable for long-term use in applications like electric vehicles and renewable energy storage.

Stability: They exhibit stable performance across a wide range of temperatures and are less prone to performance degradation at high temperatures.

Environmental Impact: LiFePO₄ batteries are considered more environmentally friendly than other lithium-ion batteries because they do not contain cobalt, which has ethical and

environmental concerns associated with its mining.

Battery Pack (4S2P)

LiFePO₄ Rechargeable Battery Pack is a 4s2p battery pack with a nominal voltage of 12V and can be fully charged upto 14.6V. This battery pack has 8 cells(4 series 18650 battery in parallel) which gives it a capacity for 1C (12A) continuous discharge and 3C (36A) discharge for a few seconds. The nominal capacity of the battery pack is 12000mah.

Nominal Voltage of battery: 12V (4s2p)

Maximum Voltage of battery: 14.6V(at full charge)

Operating Voltage : 8.4V -14.6V

Minimum voltage allowed by BMS: 8.4V*

Continuous Current Capacity: 12 A (1C)

Peak Current Capacity: 36 A (3C, only for few seconds)

Nominal Battery Capacity: 12000mAh

Maximum Charging Current(Continuous): 1C (12A)



Powering Motion : BMS and Charging

Battery Management Systems (BMS) and battery charging circuits play crucial roles in optimizing the performance, safety, and longevity of rechargeable battery systems. They ensure efficient energy storage and delivery, enhance system reliability, and contribute to the widespread adoption of battery-powered technologies in various applications.

Battery Management System (BMS)

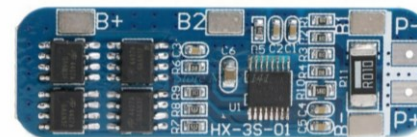
A Battery Management System is a critical component in modern battery-powered systems, including electric vehicles (EVs), renewable energy storage systems, and portable electronics. The primary function of a BMS is to monitor, control, and optimize the performance of individual battery cells within a battery pack.

- 1. Cell Monitoring:** The BMS continuously monitors the voltage, current, and temperature of each battery cell in the pack. This data helps ensure that cells operate within safe limits and prevents issues such as overcharging, over-discharging, and overheating.
- 2. State of Charge (SoC) Estimation:** By analyzing voltage and current measurements, the BMS calculates the State of Charge (SoC) of the battery pack. SoC estimation is crucial for providing accurate range predictions in EVs and ensuring efficient use of stored energy.
- 3. Cell Balancing:** Over time, individual cells in a battery pack can experience slight variations in capacity or performance. The BMS performs cell balancing, redistributing charge among cells to ensure uniform SoC and prolong overall battery life.
- 4. Safety Protections:** In addition to monitoring parameters, the BMS includes safety features such as overvoltage protection, undervoltage protection, and thermal management. These protections help prevent battery damage, improve safety, and mitigate the risk of thermal runaway.
- 5. Communication and Control:** Many BMSs support communication protocols like CAN (Controller Area Network) or SMBus (System Management Bus) to exchange data with other vehicle or system components. This enables real-time monitoring and control of battery performance.

Battery Charging Circuits

Battery charging circuits are responsible for safely and efficiently charging rechargeable batteries, such as lithium-ion (Li-ion) batteries commonly used in EVs, smartphones, and other portable devices.

- 1. Constant Current/Constant Voltage (CC/CV) Charging:** Most modern battery chargers use a CC/CV charging profile. Initially, the charger delivers a constant current to the battery until it reaches a predefined voltage (usually the battery's maximum voltage). Then, the charger switches to constant voltage mode, maintaining the voltage while reducing the charging current as the battery approaches full capacity.
- 2. Temperature Monitoring:** Good battery chargers incorporate temperature sensors to monitor the battery's temperature during charging. Charging current may be adjusted based on temperature to prevent overheating and ensure safe charging.
- 3. Charge Termination:** Charging circuits include mechanisms to detect when the battery is fully charged and automatically terminate the charging process. This prevents overcharging, which can degrade battery health and pose safety risks.
- 4. Safety Features:** Battery charging circuits often include safety features like short-circuit protection, overcurrent protection, and thermal shutdown to safeguard against potential hazards during the charging process.
- 5. Efficiency and Performance:** Advanced charging circuits optimize charging efficiency, minimize charging time, and maximize battery lifespan by employing efficient power conversion techniques and adaptive charging algorithms.



Hub Motor and Controller

A hub motor and controller system rated at 24V and 350W is a common setup used in electric vehicles, particularly in electric bicycles and scooters. The hub motor provides direct drive to the wheel, while the controller manages power delivery and motor operation, ensuring smooth and responsive performance for electric vehicle applications.

Hub Motor

A hub motor is an electric motor integrated into the wheel hub of a vehicle. In the case of electric bicycles or scooters, the hub motor is typically housed within either the front or rear wheel hub. Hub motors eliminate the need for a transmission system and can provide direct drive to the wheel, improving efficiency and reducing maintenance.

1. **Power Rating:** The motor is rated at 350W, indicating its maximum power output under normal operating conditions.
2. **Voltage:** Designed to operate at a nominal voltage of 24V, suitable for electric vehicles powered by 24V battery systems.
3. **Brushless Design:** Most modern hub motors are brushless, offering increased efficiency, reliability, and reduced maintenance compared to brushed motors.
4. **Integrated Design:** The motor is compact and integrates seamlessly into the wheel hub, contributing to a clean and streamlined vehicle design.
5. **Torque Characteristics:** Hub motors can provide good torque directly to the wheel, allowing for smooth acceleration and efficient operation.
6. **Regenerative Braking:** Some hub motors support regenerative braking, allowing them to recover energy during braking and feed it back into the battery system.

Controller

The controller is an essential component that regulates the power delivery from the battery to the motor, ensuring smooth and controlled operation of the electric vehicle. The controller for a 24V, 350W system is designed to manage the electrical current and voltage levels according to the motor's specifications.

1. **Voltage Regulation:** The controller manages the battery voltage to deliver the appropriate voltage and current to the motor.
2. **Speed Control:** It regulates the motor speed based on input from the throttle or other speed control mechanisms.
3. **Protection Features:** The controller may include protection features such as overcurrent protection, overvoltage protection, and thermal management to safeguard the motor and other components.
4. **Compatibility:** Designed to work specifically with the rated voltage and power of the hub motor to optimize performance and efficiency.
5. **Control Interfaces:** Controllers often have interfaces for throttle input, brake input (for regenerative braking), and other control signals.
6. **Efficiency:** A good controller maximizes the efficiency of the motor system, translating electrical energy from the battery into mechanical power with minimal losses.



Electric Differential Technology

Electric differential technology refers to an innovative approach to differential systems used in electric vehicles (EVs) and other electric propulsion systems. Unlike traditional mechanical differentials found in internal combustion engine vehicles, electric differentials leverage electric motors and advanced control systems to optimize vehicle dynamics, traction, and efficiency. Here's an overview of electric differential technology:

Concept and Functionality

Electric differentials use electric motors integrated into each wheel or axle of a vehicle to control torque distribution independently. By modulating the speed and torque of each wheel, electric differentials can achieve various functionalities similar to traditional mechanical differentials, such as:

1. **Torque Vectoring:** Electric differentials can vary torque distribution between left and right wheels to enhance vehicle stability, cornering performance, and overall handling.
2. **Yaw Control:** By adjusting torque to individual wheels, electric differentials can control the vehicle's yaw rate, improving maneuverability and responsiveness.
3. **Limited-Slip Functionality:** Electric differentials can simulate limited-slip differential behavior by directing torque to wheels with better traction, enhancing vehicle stability and traction control in challenging road conditions.

Types of Electric Differential Systems

1. **Single Motor Differential:** Utilizes a single electric motor connected to a differential mechanism to distribute torque between wheels on the same axle.
2. **Dual Motor Differential (Independent Drive):** Each wheel or axle is equipped with its own electric motor, providing precise control over torque distribution for optimal performance and efficiency.
3. **Torque Vectoring Systems:** Advanced electric differential systems can actively vary torque distribution based on driving conditions, vehicle dynamics, and driver inputs to optimize traction and handling.

Advantages of Electric Differentials

1. **Enhanced Performance:** Electric differentials improve vehicle performance by enabling precise control over torque distribution, resulting in better acceleration, cornering stability, and off-road capability.
2. **Efficiency and Regenerative Braking:** Electric differentials contribute to overall vehicle efficiency by enabling regenerative braking and optimized power delivery to wheels based on driving conditions.
3. **Flexibility and Adaptability:** Electric differential systems can be integrated with advanced vehicle stability control and traction management systems, enhancing safety and driver assistance features.

Dual Motor Differential

A dual motor differential setup with independent drive offers unique capabilities in terms of navigation and control in electric vehicles. In this configuration, each wheel or axle is equipped with its own electric motor, allowing for precise control over torque distribution and wheel speeds. Here's a deeper look into how navigation and control are achieved in this setup:

Torque Distribution and Control

One of the key advantages of a dual motor differential system is the ability to independently control the torque applied to each wheel. By adjusting the speed and torque output of each electric motor, the vehicle can achieve various maneuvers and navigate challenging terrain more effectively.

1. **Turning and Steering Control:** To navigate corners and turns, the vehicle can adjust the speed of each wheel independently. For example, when making a sharp turn, the outer wheel can be slowed down while the inner wheel speeds up, allowing for tighter turns without skidding or loss of control.
2. **Dynamic Stability and Traction Control:** By varying the torque distribution between the wheels, the vehicle can optimize traction and stability on different road surfaces. For instance, if one wheel encounters slippery terrain, the motor controlling that wheel can reduce torque to prevent wheel spin and maintain traction.

Regenerative Braking and Stability

Dual motor differential systems can also incorporate regenerative braking, where energy is recovered during braking by reversing the electric motors. This not only improves energy efficiency but also enhances stability and control during deceleration.

Navigation and Maneuverability

The ability to independently drive each wheel offers enhanced maneuverability and navigation capabilities, especially in tight spaces or challenging environments. Vehicles equipped with this system can perform precise movements, such as rotating in place (zero-radius turns) or adjusting wheel speeds to navigate obstacles.

Motor Control and Coordination

The motors in a dual motor differential setup are controlled by a sophisticated motor control system. This system coordinates the operation of each motor based on inputs from sensors, such as wheel speed sensors and steering angle sensors, as well as driver inputs (e.g., throttle and brake commands).

Overall Benefits

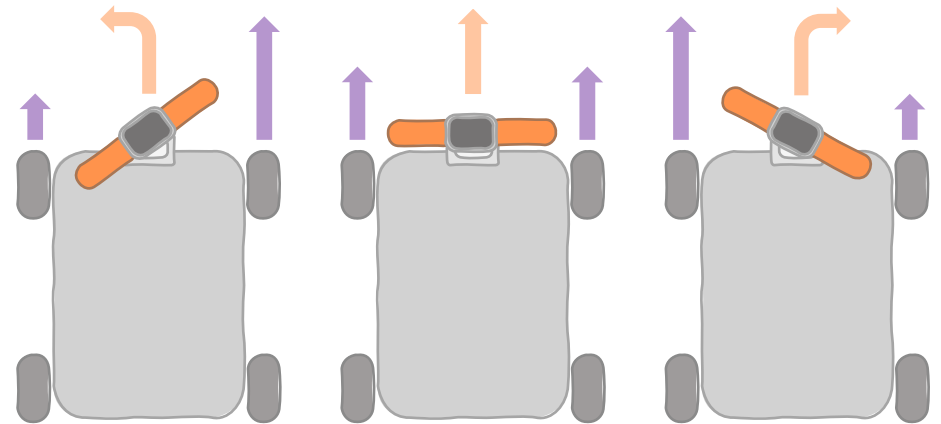
Enhanced Performance: Precise torque control allows for optimal performance in various driving conditions.

Improved Efficiency: Regenerative braking and torque vectoring enhance energy efficiency and extend battery range.

Better Traction and Stability: Independent wheel control enhances traction and stability on diverse road surfaces.

Enhanced Maneuverability: The ability to control each wheel independently enables agile and precise maneuvering.

This technology provides superior performance, efficiency, and maneuverability, making it ideal for a wide range of applications, from electric bicycles and scooters to electric cars and off-road vehicles.



Charging Time and Discharging Time

To calculate the charging time of a 12V battery with a capacity of 12000mAh using a 2A charger, and to estimate the discharge time when powering two 12V MY6812 motors, we'll use basic electrical formulas.

Charging Time Calculation:

Step 1: Convert Battery Capacity to Ampere-hours (Ah)

The battery capacity is given as 12000mAh (milliampere-hours).
Convert this to ampere-hours (Ah) by dividing by 1000:
Battery Capacity (Ah) = 12000 mAh
12000 mAh = 12 Ah

Step 2: Determine Charging Current (I) The charging current is given as 2A (amperes). For better performance 5A Charging Circuit can be used

Step 3: Calculate Charging Time (T)

Charging Time (hours) = Battery Capacity (Ah) / Charging Current (A)
Charging Time = 12 Ah / 2 A = 6 hours

Therefore, the charging time for a 12V battery with a capacity of 12000mAh (12Ah) using a 2A charger is approximately 6 hours. Using a 5A will bring down charging time to 2 hours and 24 minutes



Electric Braking

Electric braking refers to [methods of braking or slowing down electric motors or vehicles using electrical means rather than mechanical friction](#). There are several types of electric braking techniques used based on the application and system requirements. Here are some common types of electric braking:

Dynamic Braking

In dynamic braking, also known as rheostatic braking, the kinetic energy of the motor or vehicle is converted into electrical energy. This is achieved by momentarily converting the motor into a generator. The generated electrical energy is dissipated as heat through resistors connected across the motor terminals. Dynamic braking is effective for rapidly stopping motors and is commonly used in applications where mechanical braking would be inefficient or impractical.

Regenerative Braking

Regenerative braking is a method where the motor's kinetic energy is converted back into electrical energy and stored for reuse. When the motor is acting as a generator, the electrical energy is fed back into the system, such as a battery or capacitor bank. This type of braking is often used in electric vehicles (EVs) and hybrid vehicles to improve efficiency and increase range by recovering energy during braking.

Plugging or Reverse Braking

Plugging involves reversing the motor's direction momentarily to quickly decelerate or stop it. By reversing the motor's phase sequence, the motor develops a braking torque that opposes its rotation. This method is effective for rapid deceleration but can generate high currents and may not be suitable for all types of motors.

DC Injection Braking

DC injection braking involves injecting DC voltage into the motor windings while the motor is running. This creates a stationary magnetic field that opposes the rotating magnetic field of the motor, thereby generating braking torque. DC injection braking is used in applications where precise braking control is required.

These electric braking techniques offer advantages such as reduced wear and tear on mechanical components, increased efficiency, and improved control over braking performance. The choice of braking method depends on factors like the type of motor, application requirements, and desired braking performance. [Here we, go for Reverse Braking.](#)

Reverse Braking

Reverse braking, also known as plugging, is a method used to quickly decelerate or stop an electric motor by reversing its rotation direction. This technique involves momentarily reversing the connections of the motor windings, causing the motor to develop a braking torque that opposes its current direction of rotation.

Here's a more detailed explanation of reverse braking:

Operation

When reverse braking is initiated, the polarity of the motor's phases is altered to create a magnetic field that opposes the existing magnetic field of the motor. This action generates a braking torque that works against the motor's rotational momentum, effectively slowing it down.

Mechanism

The reverse braking mechanism involves switching the motor's power supply connections. Instead of applying voltage to accelerate the motor, the voltage is briefly reversed to decelerate or stop the motor. This causes the motor to act against its own momentum, converting kinetic energy into electrical energy.

Disadvantages

While reverse braking can be effective for quickly stopping motors, it has some limitations and disadvantages. One major drawback is the generation of high currents during braking. The sudden reversal of current flow can lead to large inrush currents, potentially stressing the motor windings and associated electrical components. Therefore, reverse braking is generally more suitable for smaller capacity motors where the impact of high currents is manageable.

Applications

Reverse braking finds applications in situations where rapid deceleration or emergency stopping is required, such as in conveyors, cranes, and other industrial equipment. It is effective for bringing machinery to a quick halt without relying solely on mechanical braking systems.

Control and Safety

Proper control and monitoring are essential when using reverse braking to ensure the safety and longevity of the motor. Overheating and excessive current draw should be monitored to prevent damage to the motor and associated electrical components.

In summary, reverse braking is a technique used to quickly stop electric motors by reversing their rotation direction. While effective for certain applications, it requires careful consideration of motor specifications and operational conditions to ensure safe and efficient braking performance.

Control System & Logic Board

By leveraging the capabilities of the Arduino Mega and a reliable dual motor driver, we can efficiently control and manage the operation of our personal mobility device, ensuring safe and responsive motor control tailored to varying terrain conditions and user requirements.

Dual Motor Driver

The dual motor driver is a crucial component responsible for controlling the speed and direction of two motors independently. This driver typically interfaces with the Arduino Mega to receive commands and signals for motor control.

Key Features

1. **Dual Motor Control:** Allows simultaneous control of two motors, enabling independent operation.
2. **PWM Control:** Supports Pulse Width Modulation (PWM) for speed control of motors.
3. **Direction Control:** Enables forward and reverse operation of motors.
4. **Current Sensing:** Provides feedback on motor current for monitoring and protection.

Functionality

1. **Motor Control:** The driver interprets commands from the Arduino Mega to adjust motor speed and direction based on user inputs or sensor feedback.
2. **PWM Generation:** Utilizes PWM signals generated by the Arduino Mega to control motor speed, adjusting the duty cycle to modulate motor power.
3. **Interface with Arduino:** Connects to the Arduino Mega via digital I/O pins to receive control signals (e.g., direction, PWM) and transmit feedback (e.g., motor status).

Arduino Mega (Logic Board):

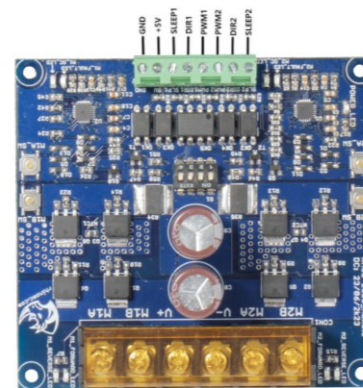
The Arduino Mega serves as the main logic board for your project, providing the intelligence and control interface for the dual motor driver and other peripheral components.

Key Features

1. **Microcontroller:** Uses the ATmega2560 microcontroller, offering ample I/O pins and memory for complex applications.
2. **Versatility:** Supports various communication protocols (e.g., UART, SPI, I2C) for interfacing with sensors, displays, and motor drivers.
3. **PWM Output:** Capable of generating PWM signals for precise motor speed control.
4. **Analog Input:** Allows analog sensor inputs for monitoring and feedback.
5. **Programming:** Programmable using the Arduino IDE, facilitating easy development and prototyping.

Functionality

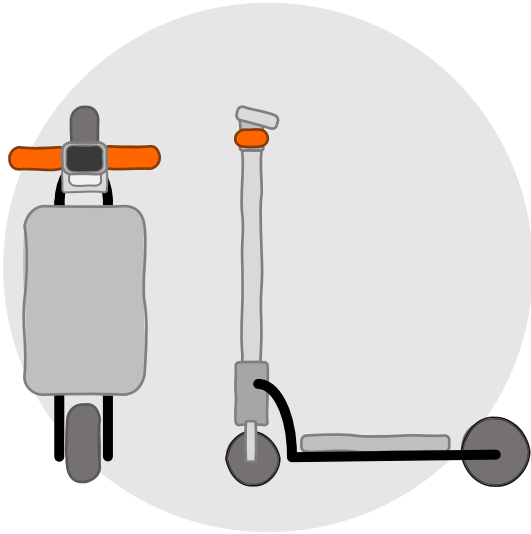
1. **Motor Control Logic:** Implements control algorithms to regulate motor speed and direction based on sensor inputs or user commands.
2. **Sensor Integration:** Interfaces with sensors (e.g., accelerometer, gyroscope) to gather data for slope detection and speed control.
3. **Communication:** Facilitates communication with the dual motor driver via digital I/O pins, sending commands and receiving motor status feedback.
4. **Data Processing:** Executes real-time data processing tasks, such as sensor fusion and PID control algorithms, to ensure responsive motor control.



CONCEPTS & EVALUATION

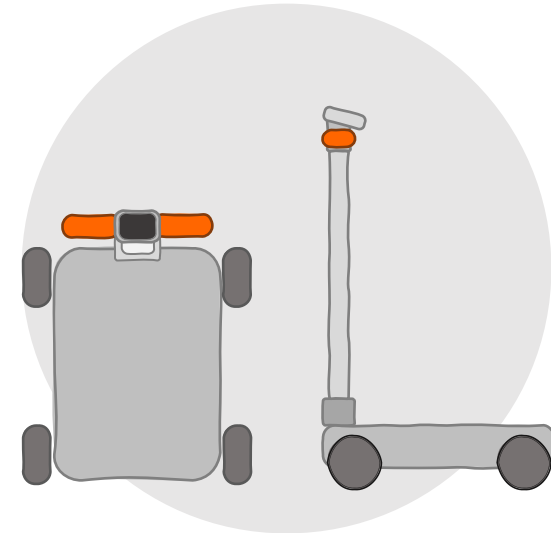
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Concepts



conceptA

Single Wheel Drive – Rear Hub
Hub Motor 24 V
Power : 24 V , 12000mah
Hub Motor Controller
Steering : Manual
Wheels : 2 , Longitudinal Configuration



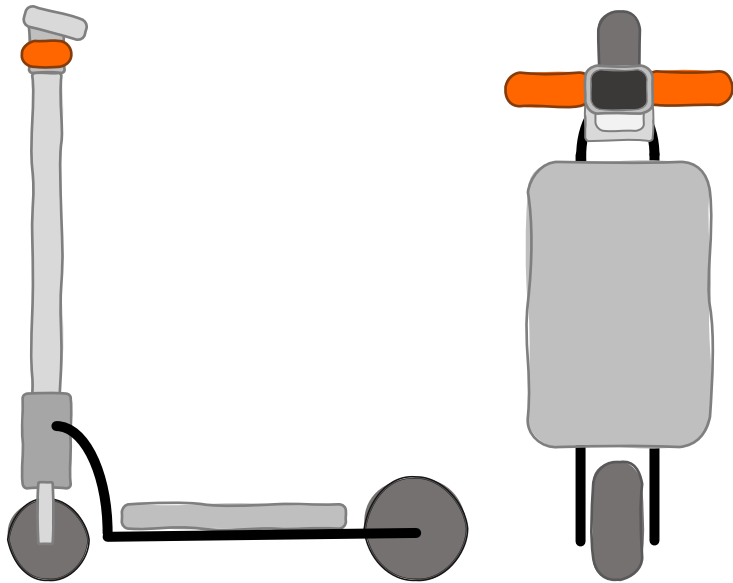
conceptB

Dual Wheel Drive – Electric Differential
2, 12V DC Brushless Motor 12V
Power : 12 V , 12000mah
Arduino Controller , Motor Driver
Steering : Electronic
Wheels : 4 , Rectangular Configuration

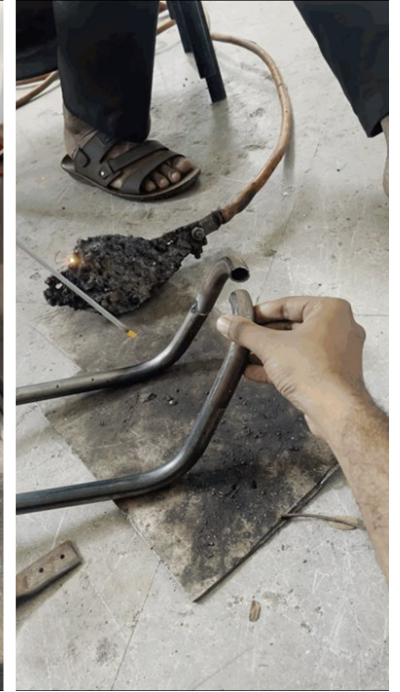
Concept A - SegScoot

conceptA

Single Wheel Drive – Rear Hub
Hub Motor 24 V
Power : 24 V , 12000mah
Hub Motor Controller
Steering : Manual
Wheels : 2 , Longitudinal Configuration



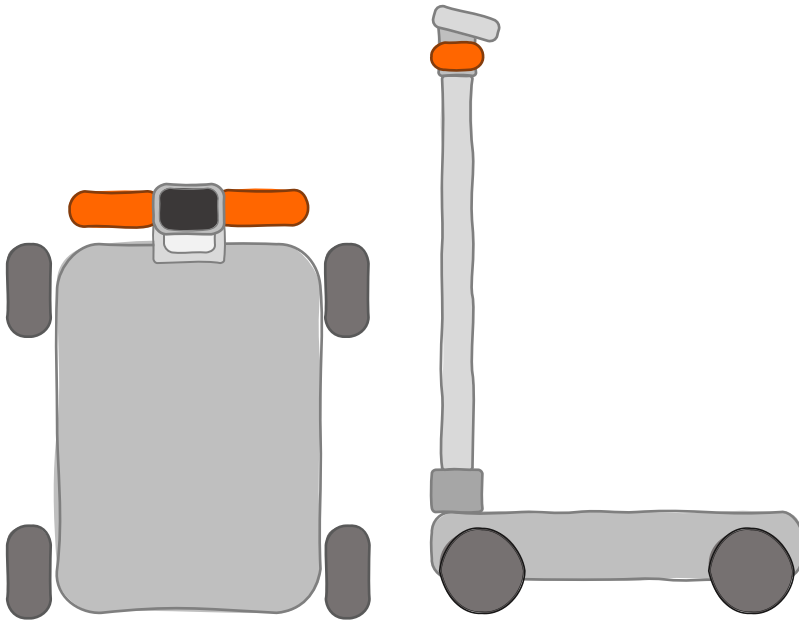
Concept A – Engineering Rig



Concept B - NeoScoot

concept **B**

Dual Wheel Drive – Electric Differential
2, 12V DC Brushless Motor 12V
Power : 12 V, 12000mah
Arduino Controller , Motor Driver
Steering : Electronic
Wheels : 4 , Rectangular Configuration



Concept B - Engineering Rig



Evaluation

To compare and select the better concept between Concept A and Concept B, I will gather feedback from a sample size of 20 individuals. After explaining the key features, appearance, cost, and technology of both products and showing visualizations, each participant will be interviewed to assess their preferences. Calculating the average score for each concept across all participants for every criterion. Radar Charts will be plotted for each interview. Final Radar Chart will be plotted with averages.

Interview Process:

Introduction and Explanation:

- Introducing both Concept A (Segway-like E scooter) and Concept B (4-wheel electric vehicle).
- Explaining features, appearance, cost, and underlying technology for each concept.
- Showing visualizations (such as images, videos, or prototypes) to provide a clear understanding.

Feedback Collection:

- Conducting individual interviews with participants.
- Asking participants to rate each concept based on predefined criteria:
- Performance (speed, acceleration, handling, range)
- Safety (stability, braking efficiency, durability, comfort)
- Cost and Affordability (prototype cost, maintenance, value for money)
- User Experience (ease of use, interface, comfort)
- Features and Technology (motor type, control system, design aesthetics)

Scoring and Analysis:

Using a rating scale (1-5) for each criterion to gather quantitative feedback.

17 Criteria for Comparison:

Performance:

- C1: Speed
- C2: Acceleration
- C3: Handling and maneuverability
- C4: Range (distance per charge)

Safety:

- C5: Stability
- C6: Braking efficiency
- C7: Durability of components
- C8: Comfort of ride

Cost and Affordability:

- C9: Manufacturing prototype cost
- C10: Potential maintenance costs
- C11: Value for money

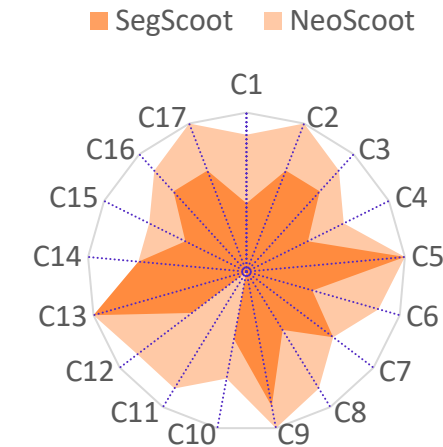
User Experience:

- C12: Ease of use
- C13: User interface (throttle control, steering)
- C14: Comfort (seating, suspension)

Features and Technology:

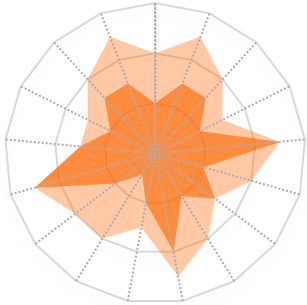
- C15: Motor type (hub motor vs. dual motor electric differential)
- C16: Control system (regular throttle vs. electronic controls)
- C17: Futuristic design elements

SEGSCOOT VS NEOSCOOT

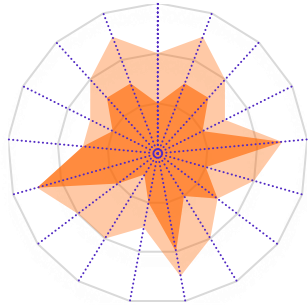


Evaluation

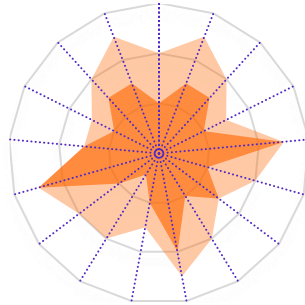
USER 11



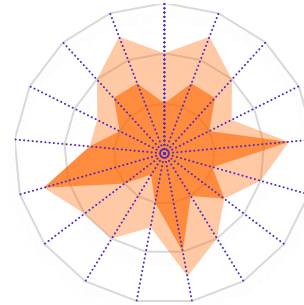
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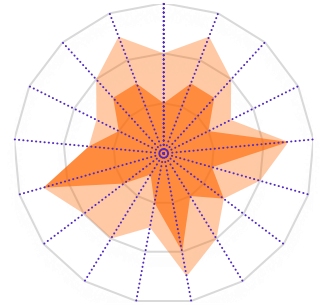
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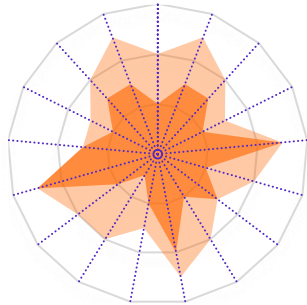
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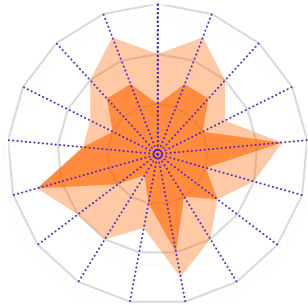
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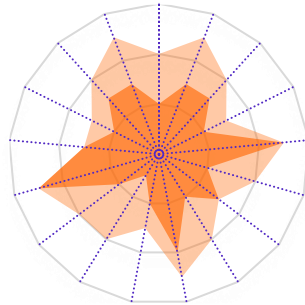
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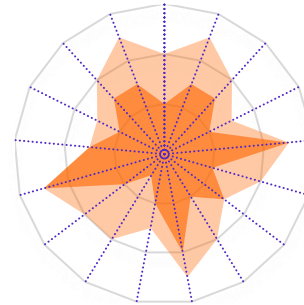
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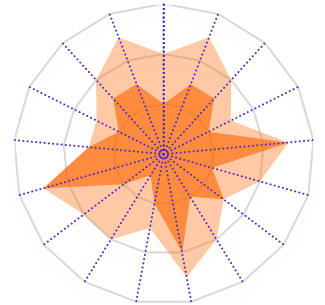
USER 18



USER 19

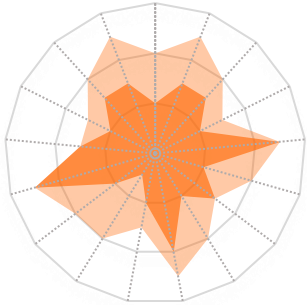


USER 20

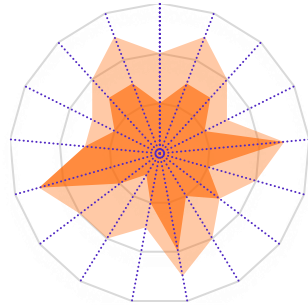


Evaluation

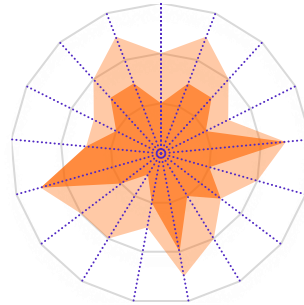
USER 1



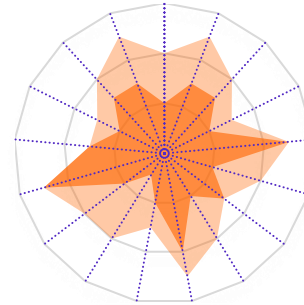
USER 2



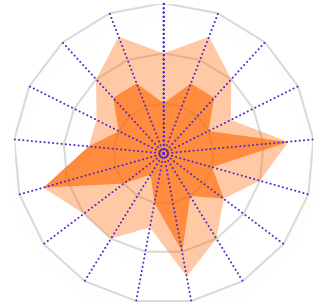
USER 3



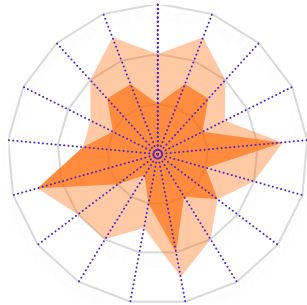
USER 4



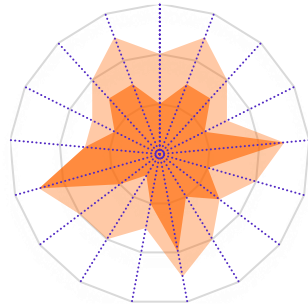
USER 5



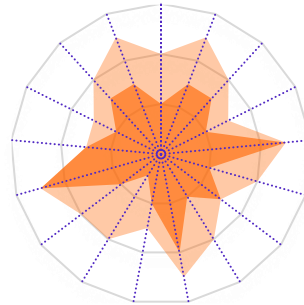
USER 6



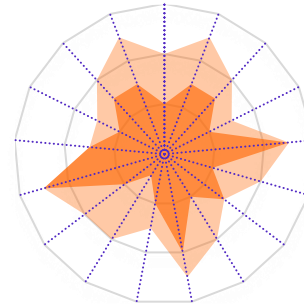
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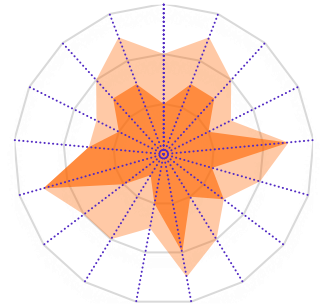
USER 8



USER 9

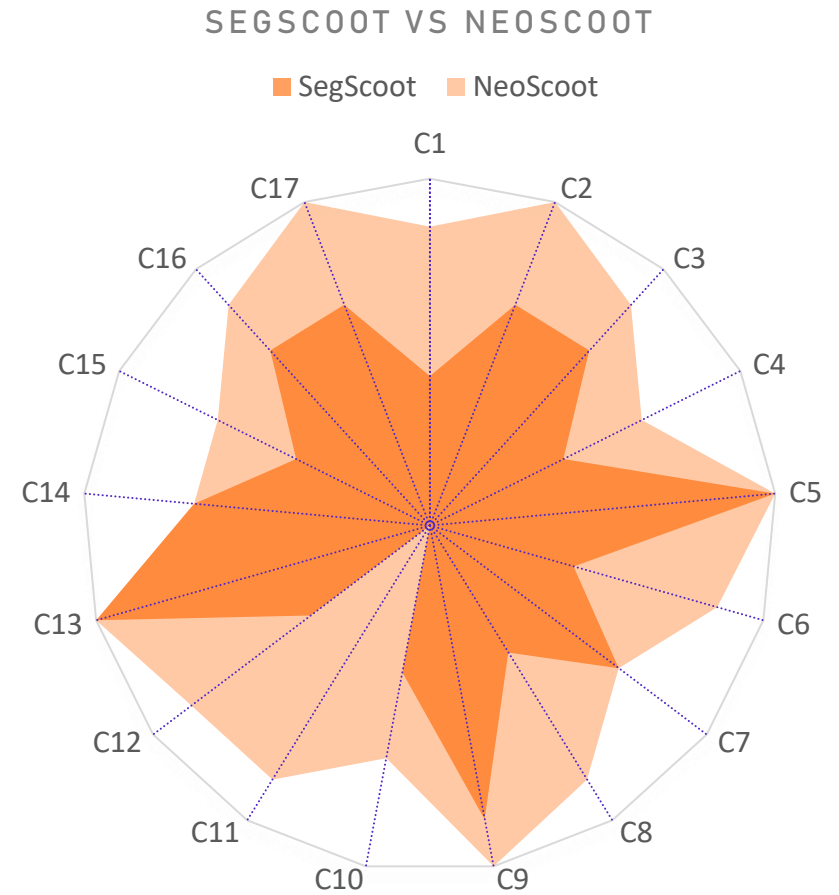


USER 10



Evaluation

Based on the evaluation performed on 20 users,
Neoscoot concept was finalized and taken further.



Final Design Brief

“

A four wheel mobility device that is featuring a dual motor front drive, is affordable compared to other modes of transport, weather responsive as that can be used in rains, effortless while riding – balance, fear of riding, compact, and that falls around price range of 15000-17000 Rs, that is “Futuristic”

”

MECHANICS & STRUCTURE

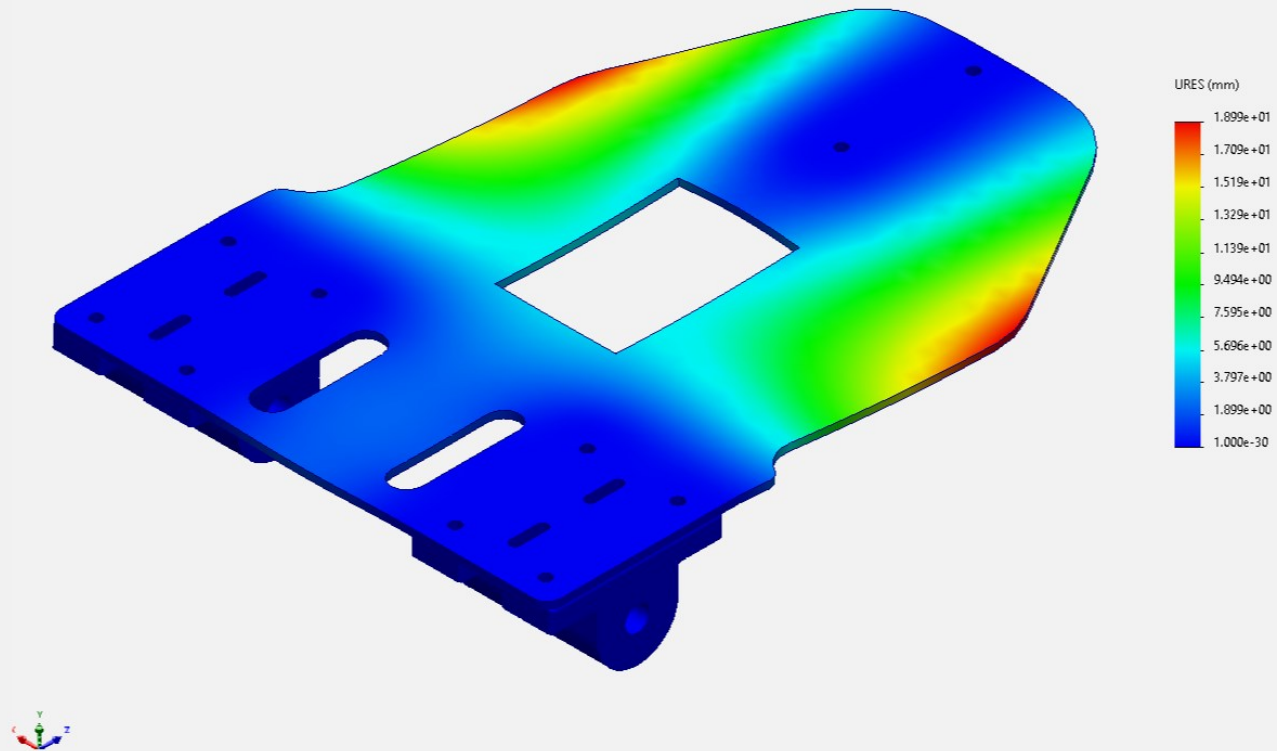
12

Finite Element Analysis

FEA Analysis

Keeping the Chasis Intact?

FEA Analysis perform on the final chasis demonstrated the capability of the Aluminium 5mm sheet to bear a load upto 150 Kgs, with a negligible deflection.



Maximum Speed

Motor Specifications:

Motor speed: 1500 RPM (no-load speed at 12V).

Gearing Ratio:

Gearing ratio: 1:3 (output shaft rotates 3 times for every 1 rotation of the motor shaft).

Wheel Diameter:

Wheel diameter: 6 inches (0.1524 meters).

Efficiency and Load:

Efficiency factor: 85% (0.85).

Load:

Calculations:

Calculate the effective speed of the vehicle based on the adjusted gearing ratio, wheel diameter, and efficiency.

Motor Speed (RPM)=1500 RPM

Gearing Ratio=3

Wheel Circumference (meters)= $\pi \times 0.1524$ meters ≈ 0.478 meters

Efficiency Factor(EF)=0.85

Vehicle Speed (m/s)= $60 \times \text{Gearing Ratio} \times \text{Motor Speed} \times \text{Wheel Circumference} \times \text{EF}$

Calculation:

Vehicle Speed (m/s)= $1500 \times 0.478 \times 3 \times 0.85$

Vehicle Speed (m/s)= $60 \times 3 \times 1500 \times 0.478 \times 0.85$ Vehicle Speed (m/s) ≈ 7.99 m/s

Vehicle Speed (km/h)= 7.99 m/s $\times 3.6$

Vehicle Speed (km/h) ≈ 28.8 km

Therefore, with a gearing ratio of 1:3, the estimated maximum speed of the vehicle with a load of 80 kg and 12V wheels (6 inches in diameter) using two MY6812 motors would also be approximately 28.8 km/h, assuming the given motor speed and efficiency factor. This calculation provides an estimate and may vary based on actual operating conditions and other factors.



ERGONOMICS & ANTHROPOMETRY

13

Ergonomics

Ergonomics focuses on designing products or systems to optimize human well-being and overall system performance. For this project, ergonomics scope include:

User Comfort

1. Designing the position, handlebars, and foot placement to minimize fatigue and strain during use.
2. Ensuring adequate padding, cushioning, and support in areas where the user comes into contact with the device.

User Interface Design

1. Placing controls, such as throttle and brake, within easy reach and in ergonomic positions for intuitive operation.
2. Designing displays or indicators to be visible and easily readable without causing distraction or eye strain.

Adjustability

1. Incorporating adjustable components (e.g., handlebars, Stem height) to accommodate users of varying sizes and preferences.

Accessibility

1. Ensuring that the device is easy to mount and dismount, especially for individuals with limited mobility or physical disabilities.
2. Considering accessibility features like step-through frames or low-profile designs.



Anthropometry

Anthropometric study involves measuring human body dimensions and proportions to optimize product design for a diverse user population. Considerations include:

User Height and Weight

1. Designing the device to accommodate a range of user heights and weights comfortably.
2. Adjusting Handlebar heights to align with common anthropometric measurements.

Reach and Range of Motion

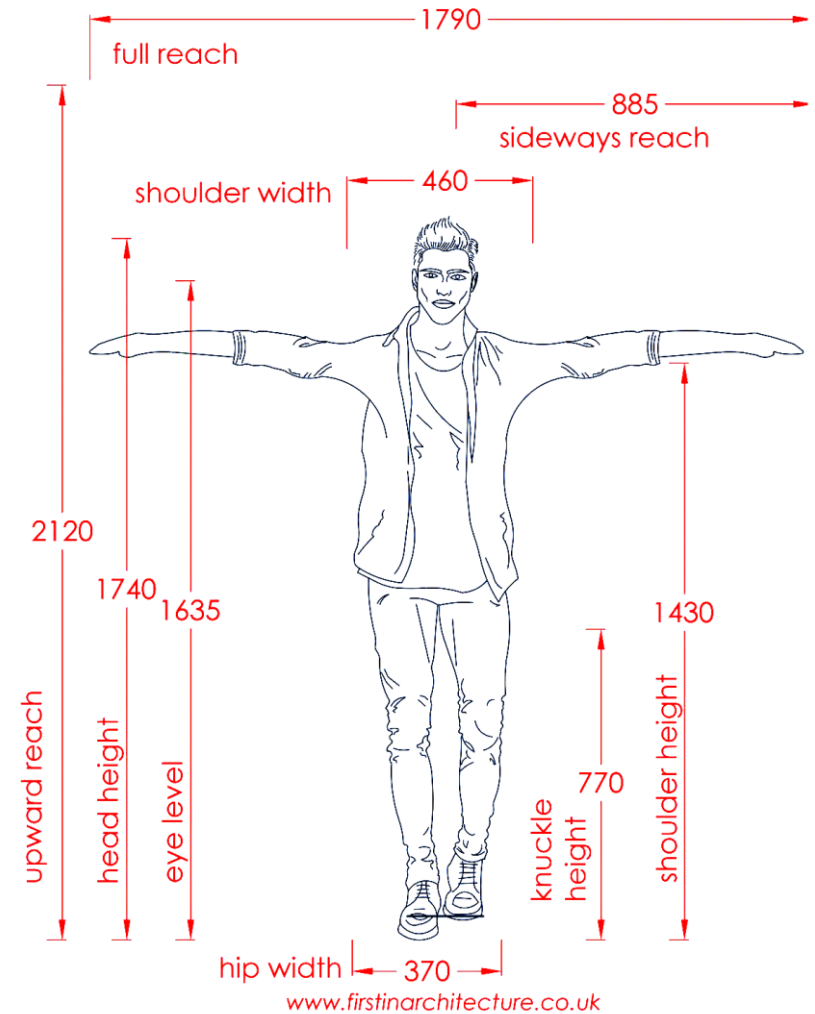
1. Analyzing reach zones to determine optimal placement of controls and components.
2. Ensuring that users can comfortably operate the device without overreaching or straining.

Legroom and Clearance

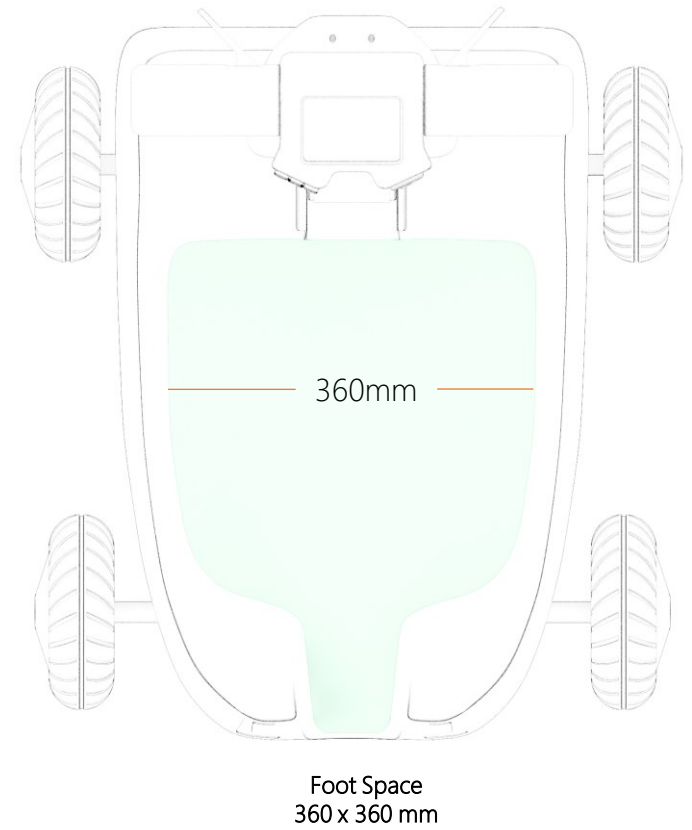
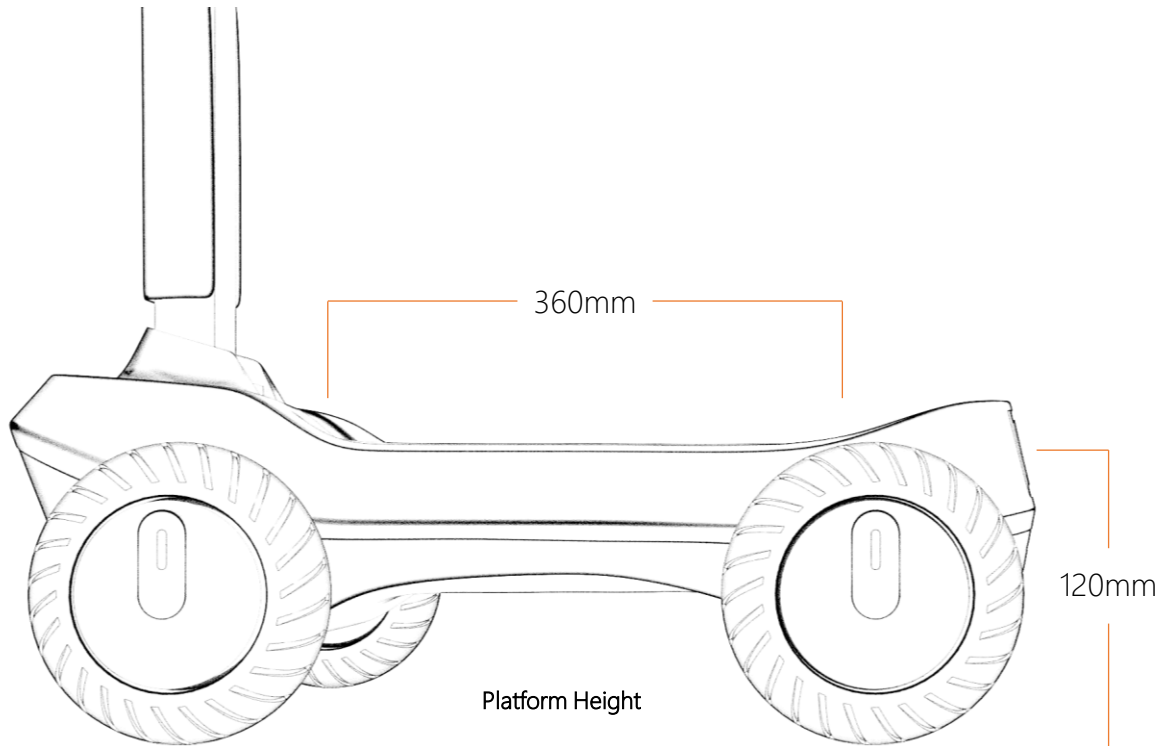
1. Providing sufficient legroom and clearance around key components to prevent discomfort or collisions.
2. Considering foot placement and ground clearance for stability and safety.

Grip and Hand Positioning

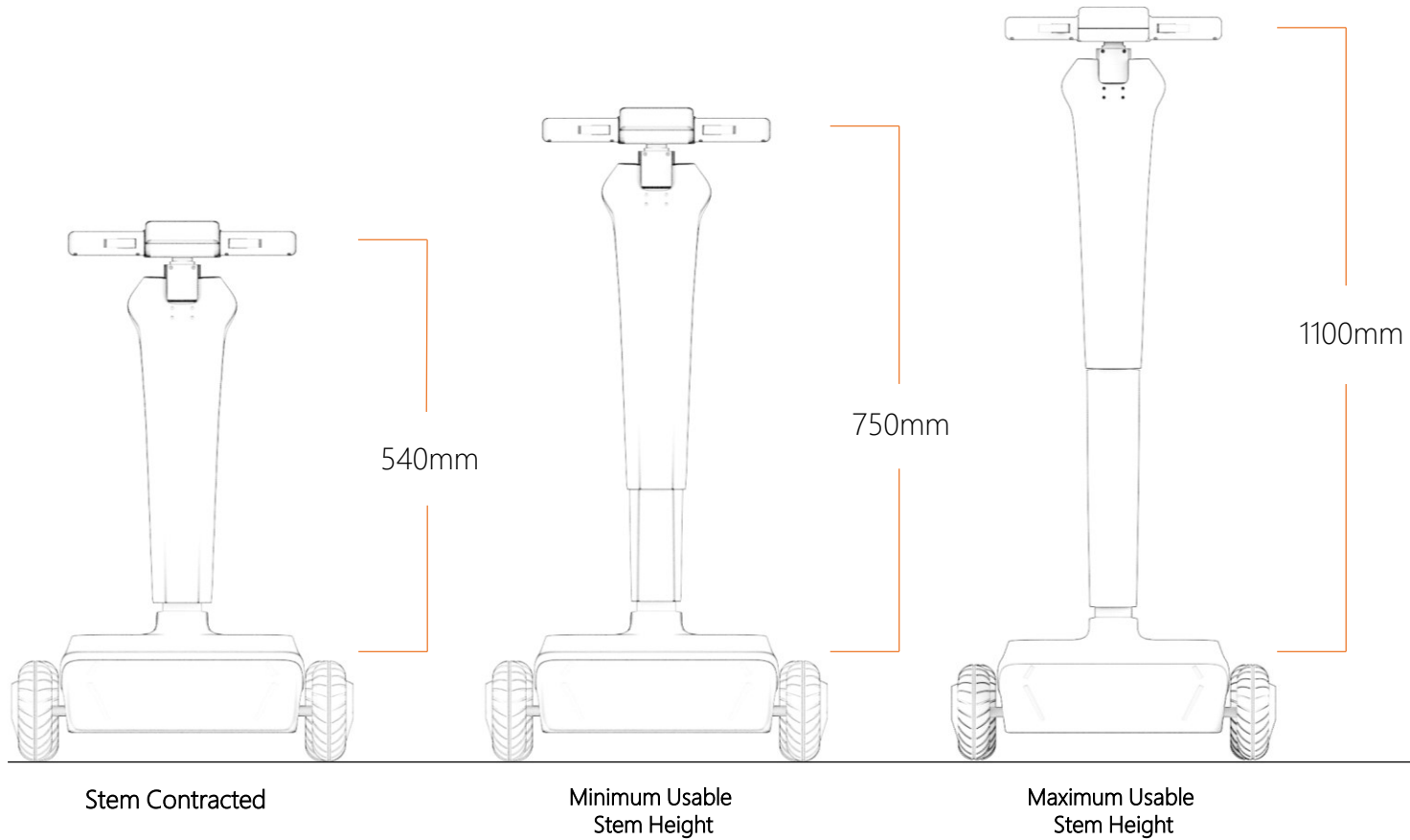
1. Designing handlebars or grips that accommodate different hand sizes and positions.
2. Evaluating handgrip angles to minimize wrist strain during operation.



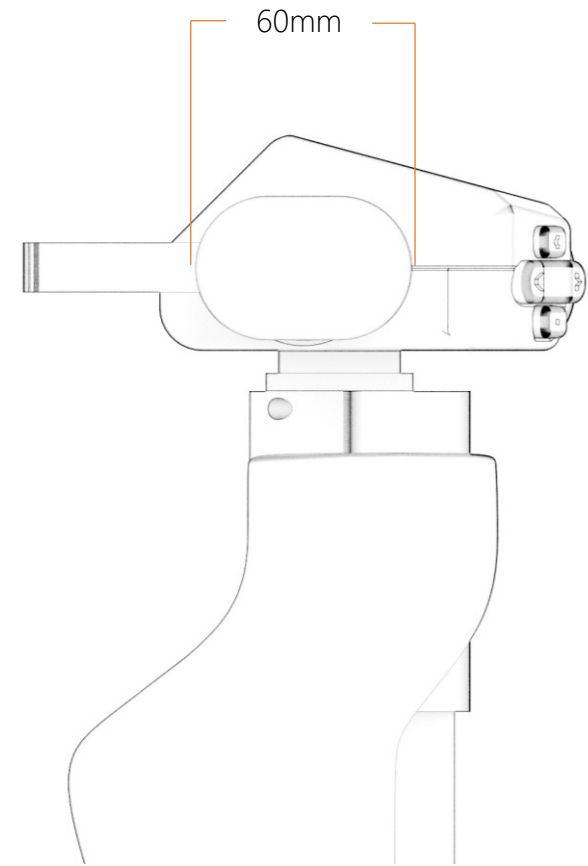
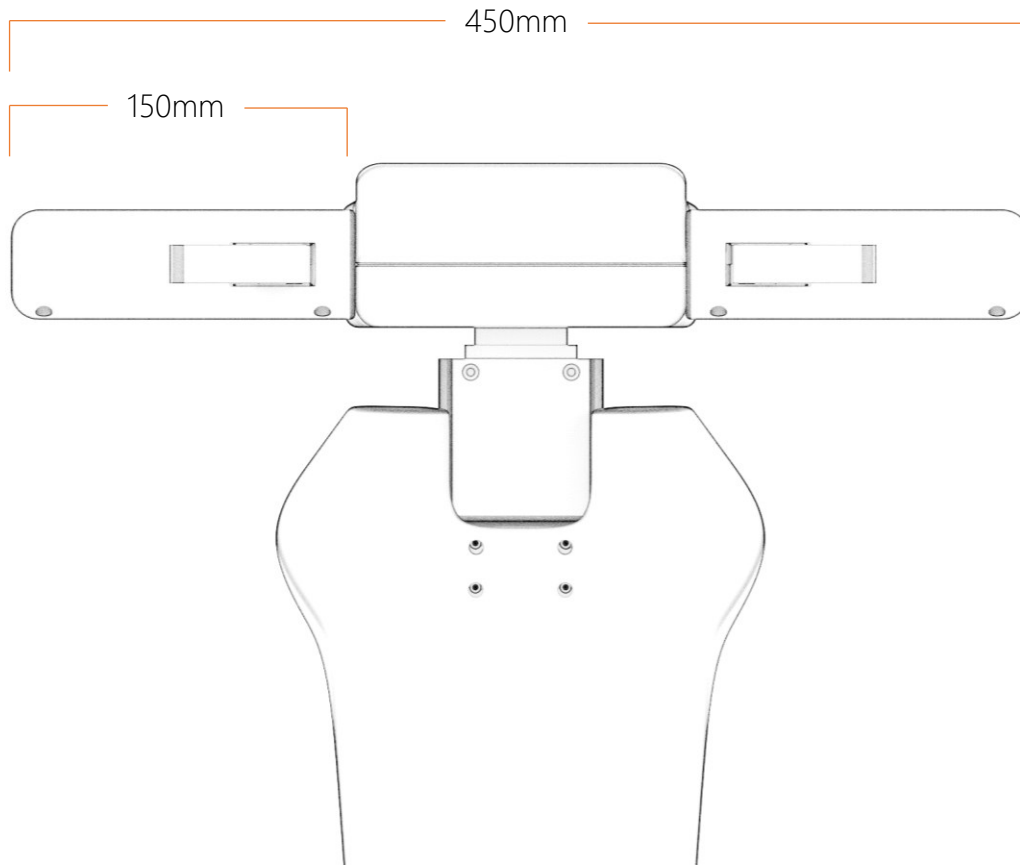
Foot Placement Ergonomics



Stem Ergonomics



Handle Ergonomics



PRODUCT ARCHITECTURE

14

Product Architecture

Product architecture refers to the fundamental structure and organization of a product's components and subsystems. It encompasses the design decisions that dictate how these elements are arranged, interconnected, and interact to achieve the product's overall functionality and performance.

Key aspects of product architecture include:

Module Hierarchy: Defines the arrangement of components into modules or subsystems, with clear interfaces and interactions between them.

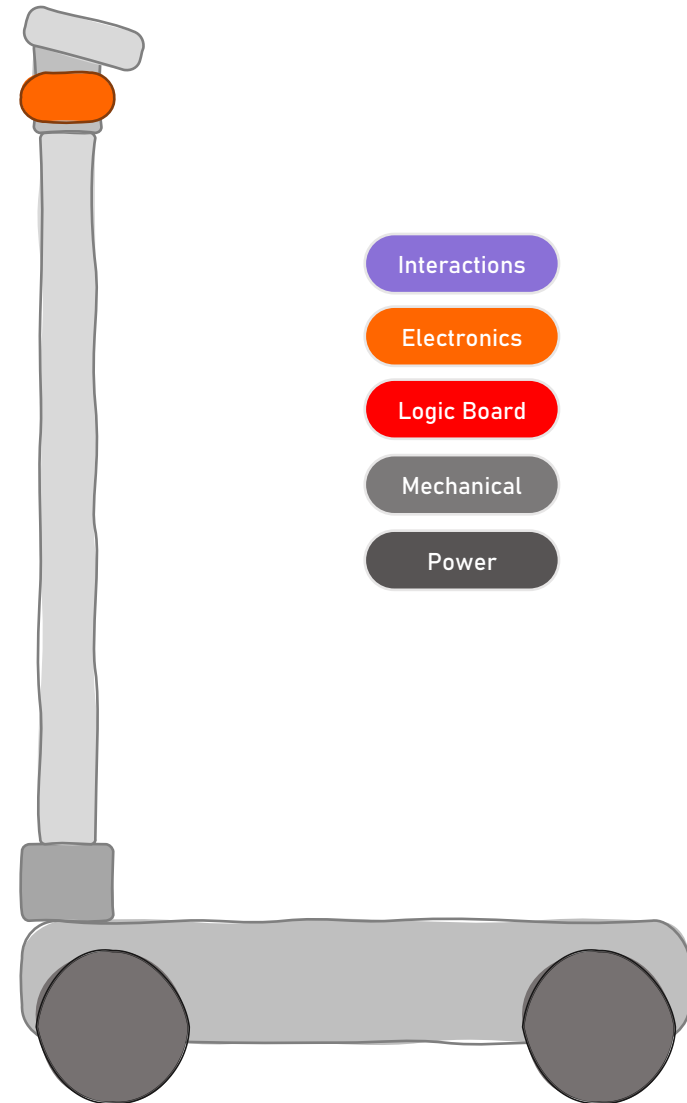
Interfaces: Specifies how different modules or subsystems connect and communicate with each other, including data flow, control signals, and power distribution.

Component Selection: Identifies the specific components and technologies used within each module or subsystem to achieve desired performance metrics.

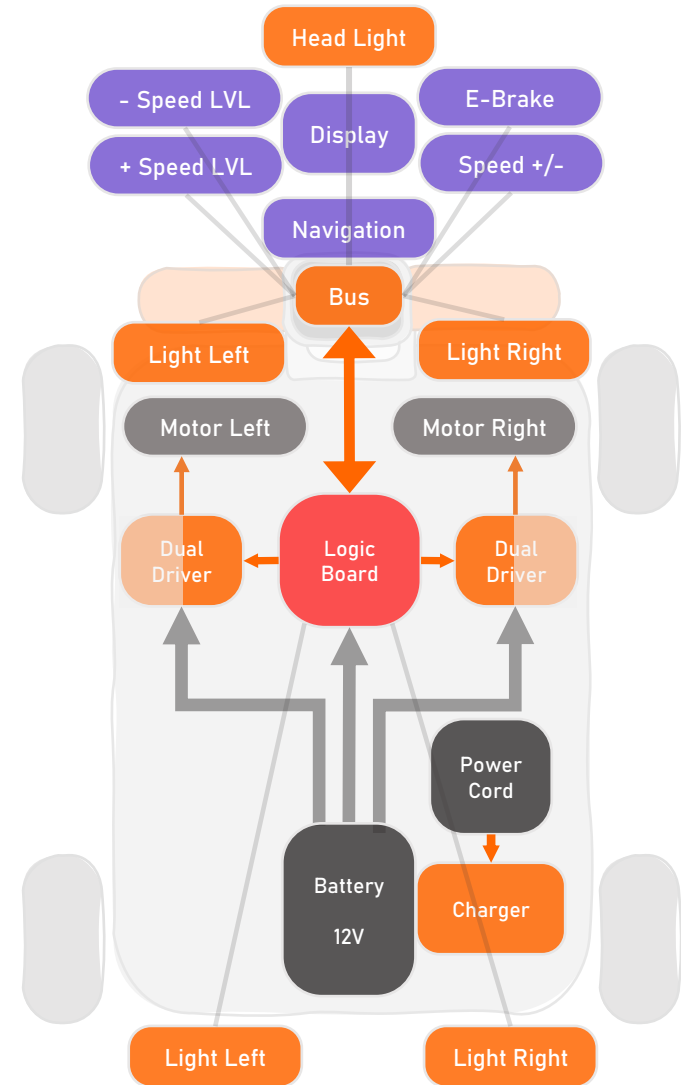
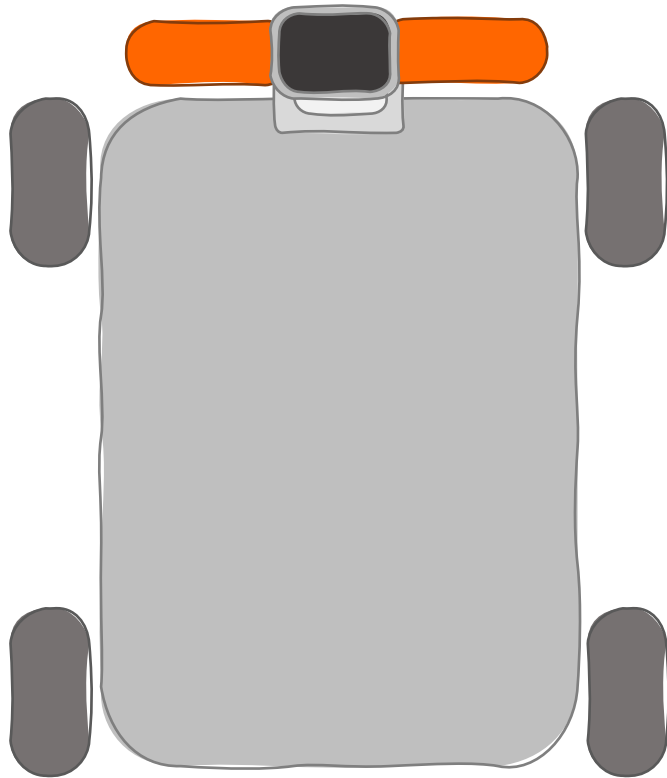
Functional Allocation: Determines which functions or capabilities are assigned to each module or subsystem, ensuring that they collectively fulfill the product's requirements.

Trade-offs: Balances competing factors such as performance, cost, manufacturability, and reliability when making design decisions.

Product architecture serves as the blueprint for the product development process, guiding the detailed design, manufacturing, and testing phases. It influences the overall system behavior, scalability, and flexibility to accommodate future enhancements or modifications.



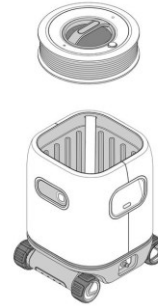
Product Architecture



FORM EXPLORATION

15

Form Moodboard



Product Element Configuration/Zoning

Product Configuration/Zoning refers to the strategic organization and layout of a product's features, components, and subsystems. It involves design decisions that determine how these elements are arranged, grouped, and allocated within the product to optimize functionality, user experience, and performance.

Key aspects of product configuration/zoning include:

Spatial Layout: Defines the physical arrangement of components, ensuring an intuitive and efficient user interface and interaction.

Functional Grouping: Clusters related functions and components together to streamline operations and maintenance.

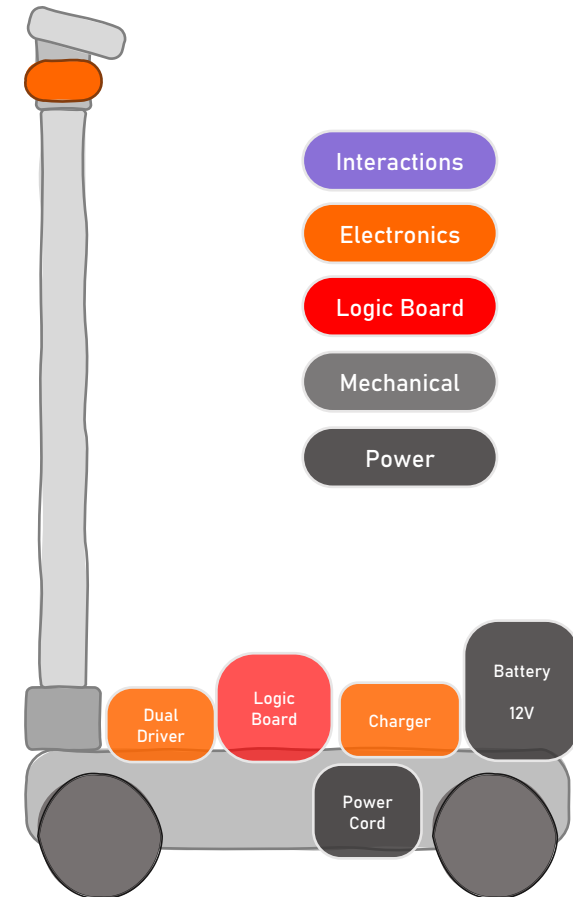
Accessibility: Ensures that essential features and components are easily accessible for users, maintenance, and upgrades.

User Flow: Organizes the product to support a logical and seamless flow of user interactions, enhancing usability.

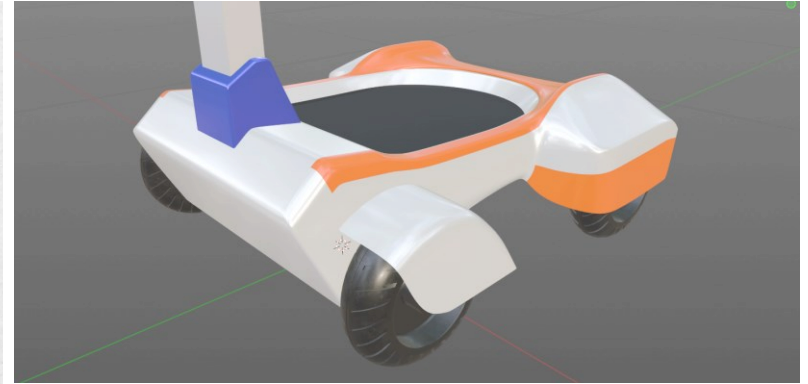
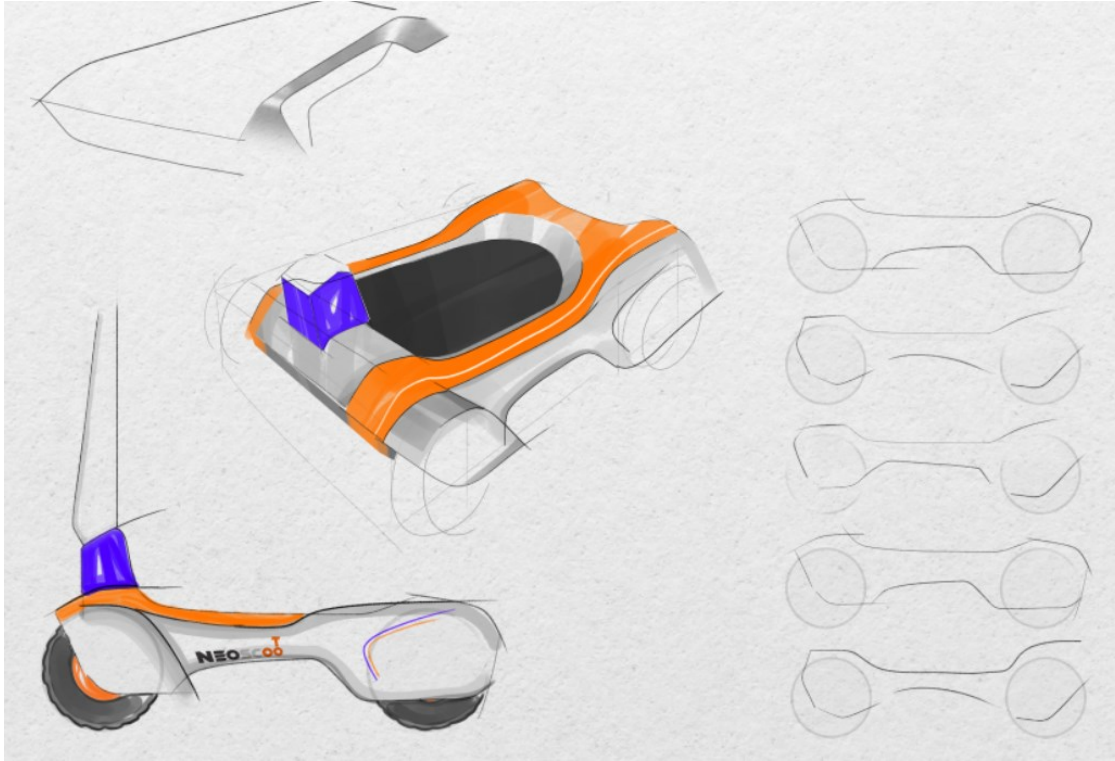
Integration: Balances the integration of components to achieve optimal performance while minimizing interference or conflicts between subsystems.

Customization: Allows for the flexible configuration of components to meet varying user needs or accommodate future modifications.

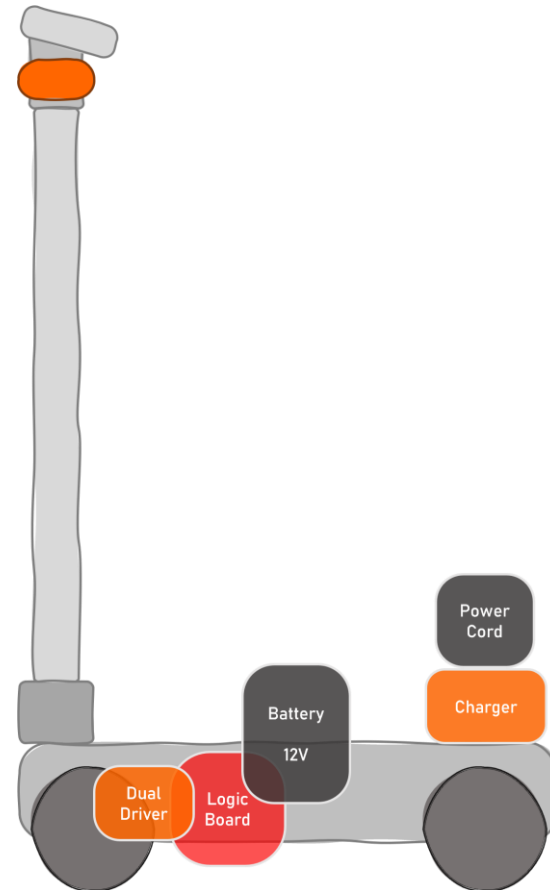
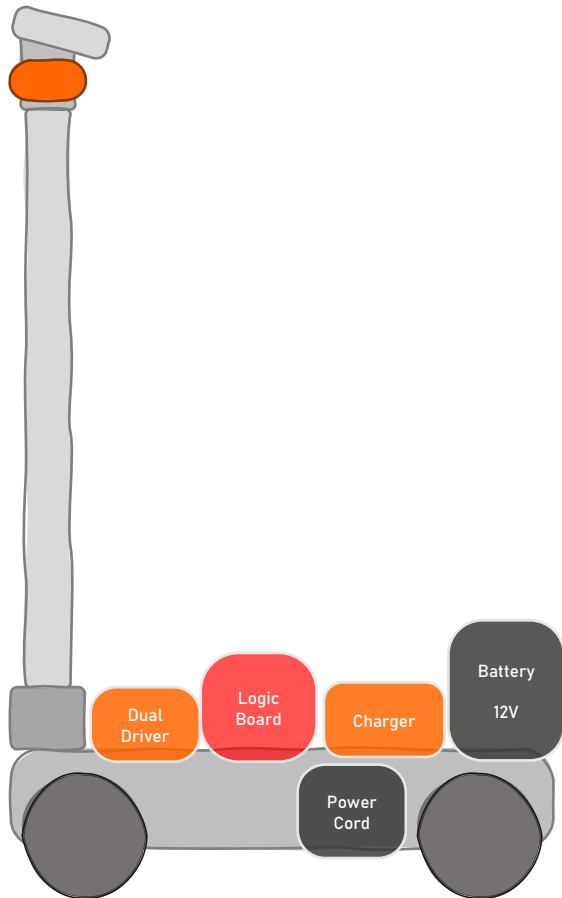
In FORM FOLLOWS FUNCTION , Product Architecture and Product Configuration play a very important role.



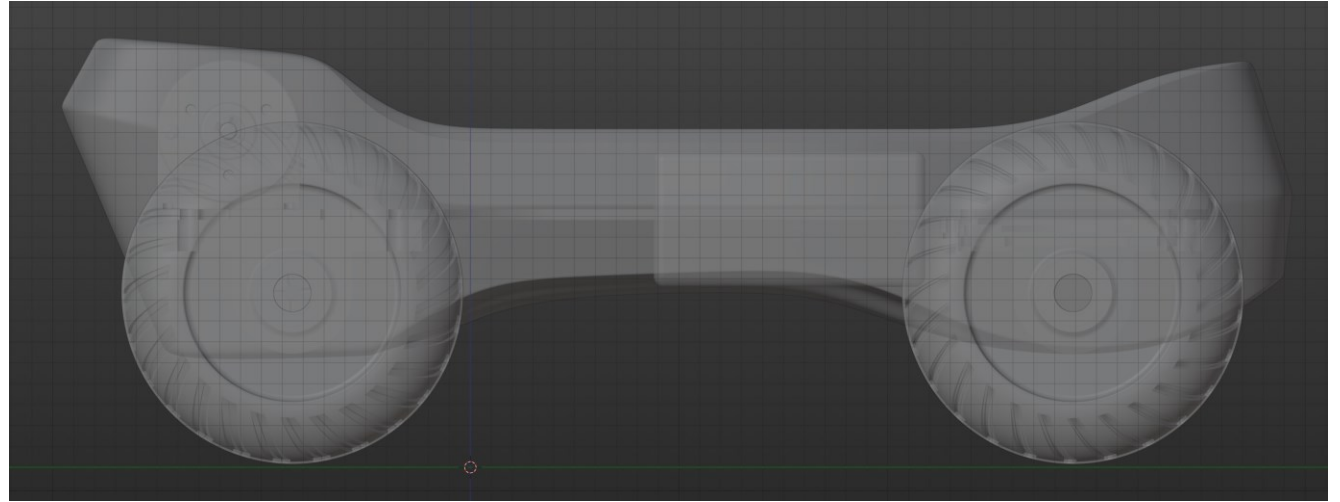
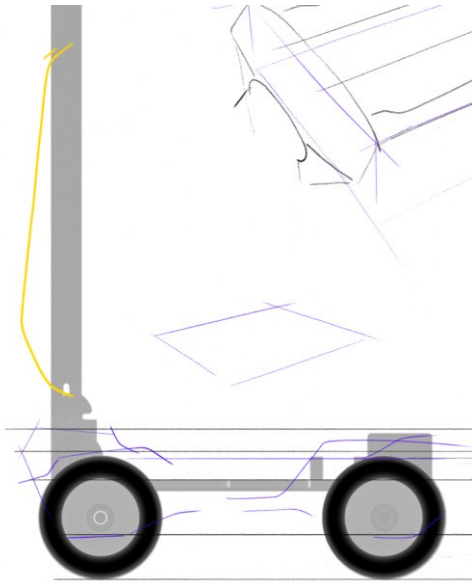
Form Ideations



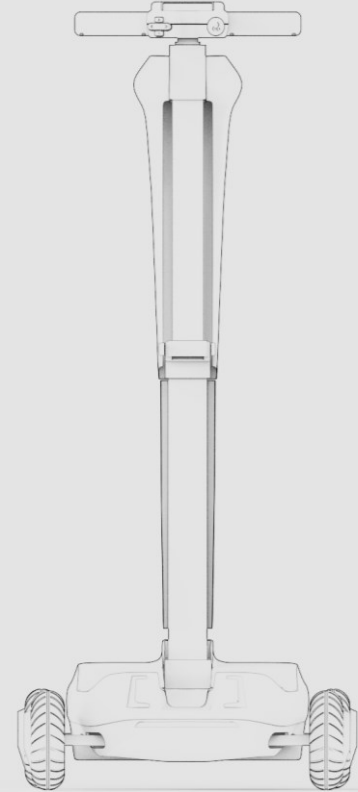
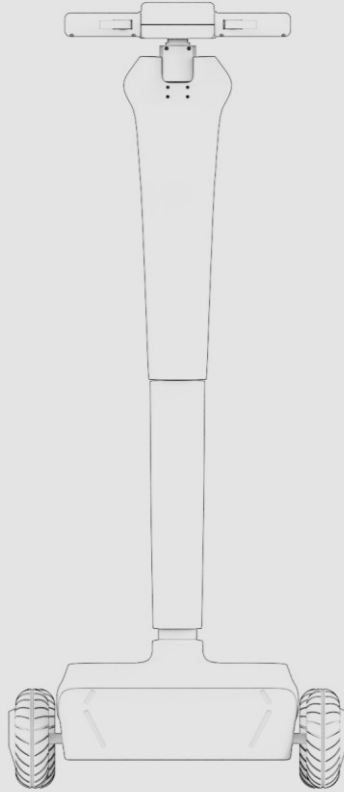
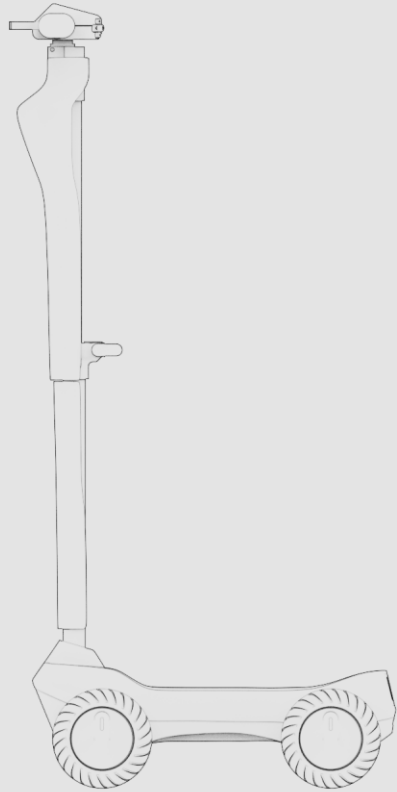
Reconfiguration



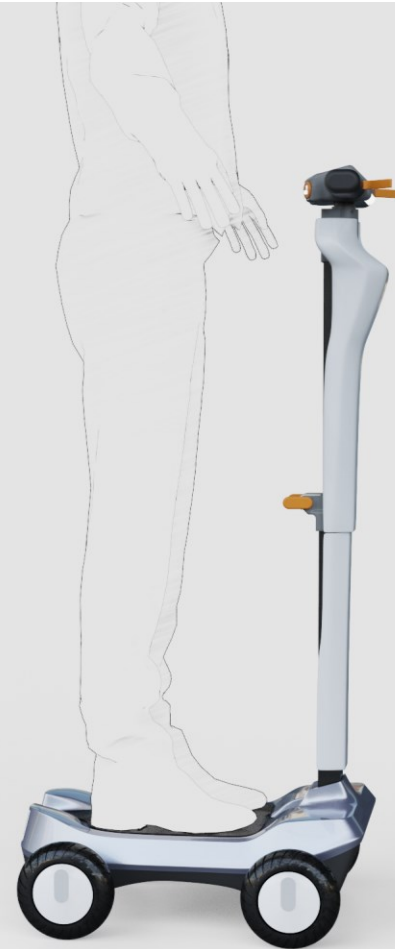
Form Ideations



Final Form



Final Form



Final Form



Final Form



Final Form



CMF EXPLORATION

16

Materials in Micro-Mobility EVs

Electric Personal Micro-Mobility Devices, have become synonymous with sustainable urban transportation, attracting interest from enthusiasts curious about their construction. These commuter tools are crafted using a blend of materials chosen for durability, lightweight properties, and performance.

Frame/Chassis

At the core of electric scooter design is the frame, typically made from aluminum alloys. Aluminum offers a balance of strength and lightness, ideal for the scooter's structure. Its corrosion resistance ensures longevity, especially in varied weather conditions.

Deck

The deck, where the rider stands, combines aluminum with reinforced composites or polymers. These materials provide a sturdy base while keeping the overall weight of the scooter manageable.

Handlebars and Stem

Steel or carbon fiber is used for handlebars and stems based on design and price considerations. Steel offers high tensile strength, while carbon fiber provides weight savings and vibration damping, enhancing maneuverability and comfort.

Plastics and Rubber Components

Plastics are used for exterior elements like fenders and light casings, adding aesthetic appeal without excessive weight. Rubber is crucial for grip and cushioning, found in handlebar grips and tires (often with Kevlar for puncture resistance).

Battery Technology

Lithium-ion batteries are standard for electric scooters due to their high energy density and longevity. These batteries contain rare metals like cobalt, nickel, and manganese, with ongoing advancements aiming for greater efficiency and eco-friendliness.

Electronics

The electronics include the motor, control board, and display unit. Copper wiring ensures efficient power transfer, while silicon and semiconductors in microcontroller chips enable speed modulation and energy management.

In summary, EVs leverage a diverse range of materials to optimize weight, durability, and performance. Aluminum alloys provide a sturdy frame, reinforced composites support the deck, and a combination of steel, carbon fiber, plastics, and rubber ensures functionality and comfort. With ongoing advancements in material science, electric scooters continue to evolve towards greater efficiency and sustainability.

Plastics used in AM industries

Polypropylene (PP)

Polypropylene (PP) is a versatile plastic widely used in automotive manufacturing for its chemical resistance, heat tolerance, and moldability. It's employed in critical components like bumper fascia, gas cans, engine covers, cable insulation, and instrument panels. PP's durability suits applications such as bumper fascia and gas cans, while its heat resistance is ideal for engine covers. It also provides electrical insulation for automotive wiring and enables lightweight, durable instrument panels with complex shapes. PP's widespread use underscores its role in enhancing automotive performance and durability.

Polyurethane (PUR)

Polyurethane, a durable plastic polymer composed of urethane units, is widely used in automotive manufacturing for its versatility and suitability in producing both complex and simple components. Commonly subjected to plastic fabrication processes like injection molding and CNC machining, polyurethane is favored for its insulative properties, strength, resilience, and moldability, making it ideal for various automotive applications. This includes parts that dampen noise and heat from car engines, as well as components requiring strength in vehicle bodies. Automotive parts made from polyurethane encompass seats, headrests, soundproofing and air filtering systems, bumpers, suspension insulators, and even tires. This extensive utilization of polyurethane highlights its importance in enhancing automotive comfort, performance, and durability.

Polyvinyl Chloride (PVC or Vinyl)

PVC (Polyvinyl chloride) is a widely used plastic polymer in the automotive industry due to its water and chemical resistance, affordability, impact resistance, and durability. However, PVC has poor heat stability and requires additives to enhance its properties, limiting its compatibility with certain applications. Despite this, PVC is commonly used in automotive components such as vehicle airbags, door panels, cables, dashboards, and upholstery, as well as for underbody protection. Its versatility and cost-effectiveness make it a practical choice for specific automotive applications despite its limitations in heat stability.

Acrylonitrile Butadiene Styrene (ABS)

ABS (Acrylonitrile Butadiene Styrene) is a high-performance automotive thermoplastic composed of three monomers: Acrylonitrile, Butadiene, and Styrene, commonly processed through ABS injection molding. This versatile polymer is known for its strength, durability, and excellent electrical insulation properties. ABS is also dyeable, enhancing its aesthetic appeal in automotive applications. It is frequently used to manufacture components like dashboards, car body parts, and wheel covers due to its desirable physical and mechanical properties. Its versatility and aesthetic qualities make ABS a popular choice for various automotive components.

Polyamide (PA/ Nylon 6/6, Nylon 6)

Nylon is extensively used in automotive part manufacturing for its strength and durability, offering excellent wear resistance and heat stability. However, nylon's high water absorption can be mitigated with additives like fiberglass. This high-performance engineering plastic is well-suited for heavy-duty automotive applications.

Common automotive parts made from nylon include engine covers, door handles, gears, and fuel caps. These components benefit from nylon's robust properties, ensuring reliability and longevity in demanding automotive environments. Despite its water absorption drawback, nylon remains a preferred material for critical automotive components due to its overall performance and durability.

Polystyrene (PS)

Polystyrene, a transparent polymer available in solid and foamed forms, boasts excellent heat and chemical resistance along with optical clarity. While mainly used for displays and panels in the automotive industry, it finds applications in various components such as car interiors, knobs, fittings, door panels, and sound dampening foam. Polystyrene's versatility and optical properties make it a preferred choice for enhancing aesthetics and functionality in automotive parts.

Plastics used in AM industries

Polyethylene (PE)

Polyethylene (PE) is a versatile and durable plastic known for its affordability, chemical resistance, and low density. It plays a crucial role in automotive part manufacturing, particularly for making plastic fuel tanks and glass-reinforced car bodies. PE's durability and chemical resistance make it a practical choice for critical automotive components. Its lightweight nature also contributes to fuel efficiency and overall vehicle performance.

Polyoxymethylene (POM)

POM (Polyoxymethylene) is a semi-crystalline plastic known for its dimensional stability across various environmental conditions and temperatures. It is rigid, chemical-resistant, UV-resistant, and has a sleek appearance. POM is used for manufacturing automotive parts requiring high precision and resistance to fuel, chemicals, and cold. It finds applications in interior and exterior trims, as well as in fuel system components due to its durability and performance characteristics.

Polycarbonate (PC)

Polycarbonate is a transparent and impact-resistant plastic widely used in the automotive industry. Known for its rigidity, durability, strength, and optical clarity, polycarbonate is versatile and can be easily thermoformed, molded, and processed. It is commonly used to manufacture automotive components such as bumpers, bullet-proof glass, and headlamp lenses due to its exceptional performance and resilience.

Acrylic (PMMA)

Acrylic is a stable automotive plastic known for its UV resistance and excellent optical clarity, making it an excellent glass alternative. It is affordable, readily available, and a suitable substitute for polycarbonate in applications where material strength is less critical. Acrylic is commonly used for automotive topcoats, car light covers, and motorcycle windshields due to its durability and optical properties.

Polybutylene terephthalate (PBT)

Polybutylene terephthalate (PBT) is a stiff, tough, and transparent material widely used in automotive part manufacturing for its insulative properties and chemical resistance. It exhibits minimal shrinkage during forming. While PBT has lower strength and rigidity compared to plastics like polyethylene terephthalate (PET), it offers better impact resistance. Common automotive applications of PBT include plug connectors, bumpers, and door handles due to its durability and performance characteristics.

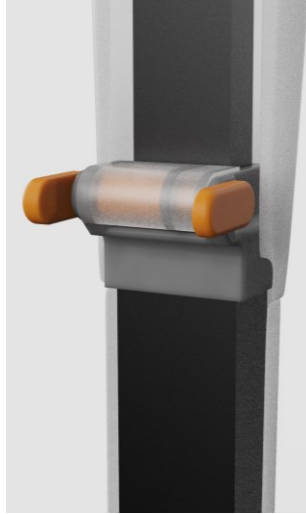
Polyethylene terephthalate (PET)

Polyethylene terephthalate (PET) is a safe automotive plastic known for its glass-like appearance, high strength-to-weight ratio, flexibility, and moisture resistance. It does not emit odors or fumes, making it suitable for various automotive applications. PET is used in manufacturing exterior body parts, casing, engine covers, connector housing, and headlamp retainers due to its durability and aesthetic qualities.

Acrylonitrile Styrene Acrylate (ASA)

ASA (Acrylonitrile Styrene Acrylate) is an amorphous thermoplastic similar to ABS but offering enhanced water resistance, higher heat, chemical, and wear resistance. It is insoluble in water and exhibits good dimensional stability and weldability. ASA is commonly used to manufacture automotive parts and components including instrument panels, interiors, and electrical parts due to its durability and performance characteristics.

CMF



HMI & INTERACTION DESIGN

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UX Principles in NeoScoot

User-Centered Design

Focus on User Needs: Neoscoot is designed with the primary focus on the needs of students and campus commuters. The device addresses common pain points like ease of use, portability, and efficiency.

Accessibility: The interface and physical controls are intuitive, ensuring that users of all skill levels can operate the scooter without difficulty.

Consistency

Consistent Interface Design: The user interface (UI) of Neoscoot's Nextion 3.5-inch display is consistent across all screens, with uniform icons and predictable interactions.

Physical Controls: The physical buttons for On/Off, Brake, Gear Up, and Gear Down are placed ergonomically and maintain a consistent layout for easy recall.

Feedback

Immediate Feedback: The display provides real-time feedback on speed, battery level, and other vital metrics, ensuring users are always informed about their ride status.

Action Confirmation: Audible or visual cues confirm user actions, such as starting or stopping the scooter, changing gears, and charging status.

Simplicity

Minimalist Design: The UI is simple and uncluttered, focusing on essential functions to avoid overwhelming the user.

Ease of Use: Features are streamlined to ensure that even those unfamiliar with technology can operate the scooter effortlessly.

Affordance

Intuitive Controls: Physical controls and the touch interface are designed to be self-explanatory, minimizing the learning curve.

Visual Clues: The design incorporates visual cues to guide users, such as arrows and icons indicating button functions.

Error Prevention and Recovery

Clear Instructions: The display provides clear instructions and feedback to prevent user errors.

Easy Recovery: If an error occurs, users are provided with straightforward instructions to correct it, reducing frustration.

Flexibility and Efficiency of Use

Customizable Settings: Users can personalize settings such as display brightness and notification preferences to suit their needs.

Efficient Navigation: Quick access to frequently used features, like starting or stopping the scooter, ensures efficient use.

Aesthetic and Minimalist Design

Modern Look: Neoscoot's design aligns with the futuristic and technological ethos of IIT Bombay, featuring a sleek and modern aesthetic.

Compact Form: The scooter is designed to be compact and portable, easily fitting into small spaces when not in use.

Visibility of System Status

Clear Display of Information: The display shows all necessary information, such as speed and battery level, in a clear and easily readable format.

Real-Time Updates: The system provides real-time updates on performance metrics, ensuring users are always aware of the scooter's status.

Help and Documentation

Accessible Help: The system includes easy-to-access help documentation and support for troubleshooting common issues.

User Guides: Instruction manuals and quick start guides are provided to help users get started and make the most of their Neoscoot experience.

UX Elements in NeoScoot

User-Centric Design

Ease of Use: The interface is designed to be intuitive and simple, ensuring that users of all ages and technical backgrounds can operate the scooter without confusion.

Clear Instructions: Labels and icons are used to clearly indicate functions, making the interface self-explanatory.

Accessibility

Large Buttons and Text: Ensures readability and ease of interaction, especially important for users with visual impairments or those riding in low-light conditions.

Responsive Design: Touchscreen and physical buttons respond quickly to user inputs, providing immediate feedback.

Safety Features

Emergency Stop: Prominently displayed "Stop" button ensures quick access in case of emergencies.

Brake Lever: Intuitive placement and design for easy use during rides.

Visual Feedback

Speed and Battery Indicators: Constant visual feedback on speed and battery status helps users make informed decisions about their ride.

Gear Indicator: Clearly shows the current gear, allowing users to adjust their speed and power efficiently.

Ergonomic Considerations

Handlebar Controls: Physical buttons for on/off, gear up/down, and braking are placed within easy reach to minimize effort and maximize control.

Display Placement: The 3.7-inch display is strategically placed for easy viewing without obstructing the rider's view of the road.

Customization and Settings

Settings Menu: Accessible via a small gear icon, allowing users to customize their experience (e.g., display brightness, notification preferences).

User Profiles: Potential to save user preferences for different riders, enhancing the personalized experience.

Aesthetic Appeal

Modern Interface Design: Sleek, minimalist design aligns with the futuristic and tech-savvy ethos of IIT Bombay.

Visual Consistency: Consistent color schemes, fonts, and iconography to maintain a cohesive look and feel.

Contextual Information

Notifications and Alerts: Real-time alerts for low battery, maintenance needs, and other important information to keep the user informed.

Environmental Adaptability: Potential to adapt the interface based on weather conditions or time of day (e.g., night mode).

User Feedback Mechanisms

Interactive Elements: Touchscreen interactions that provide haptic or audio feedback to confirm actions.

Surveys and Feedback Forms: Integrated within the settings menu to gather user feedback for continuous improvement.

Integration with Physical Components

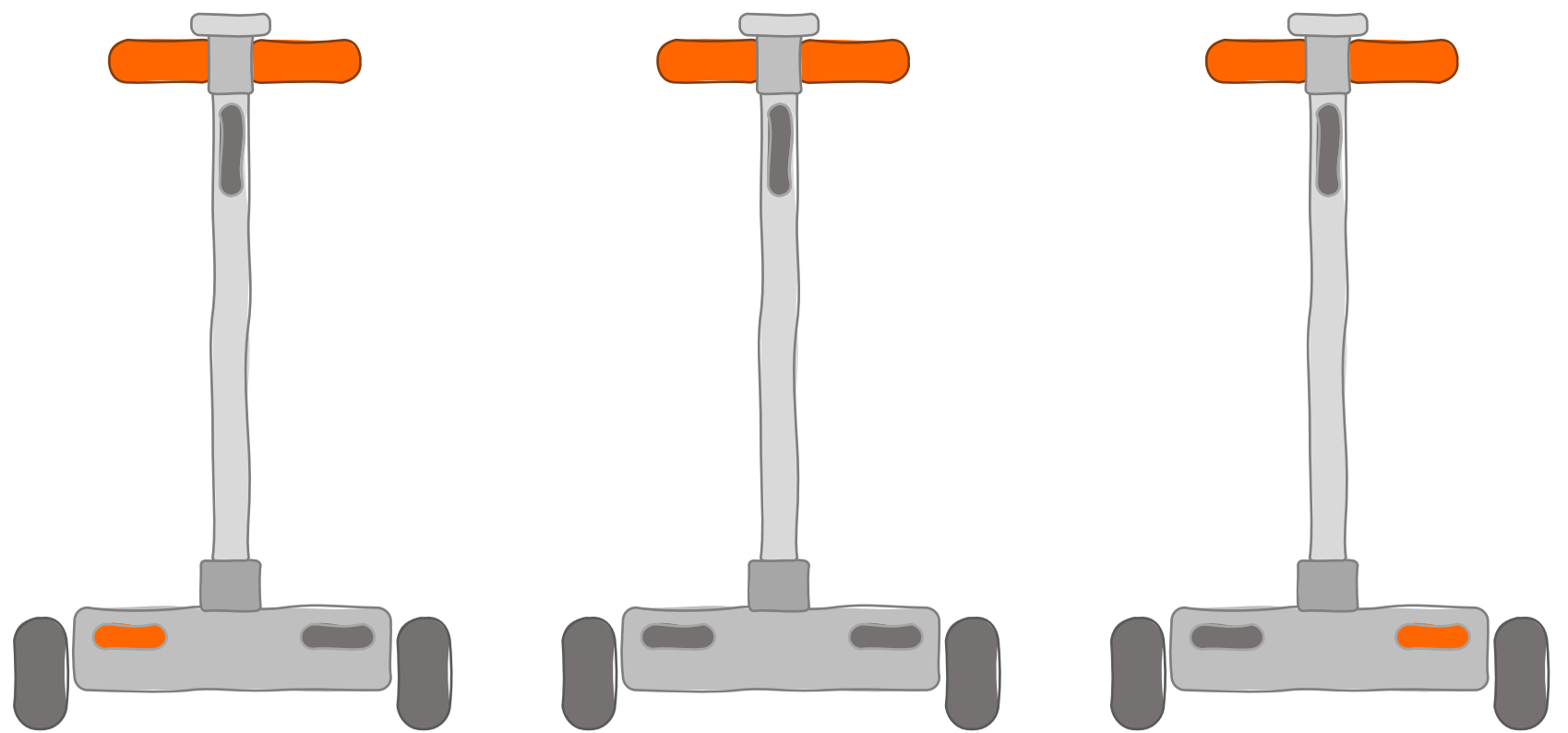
Seamless Interaction: The digital interface complements physical controls, creating a cohesive user experience that bridges the gap between hardware and software.

Charging Indicators: Visual representation of charging status when the scooter is plugged in.

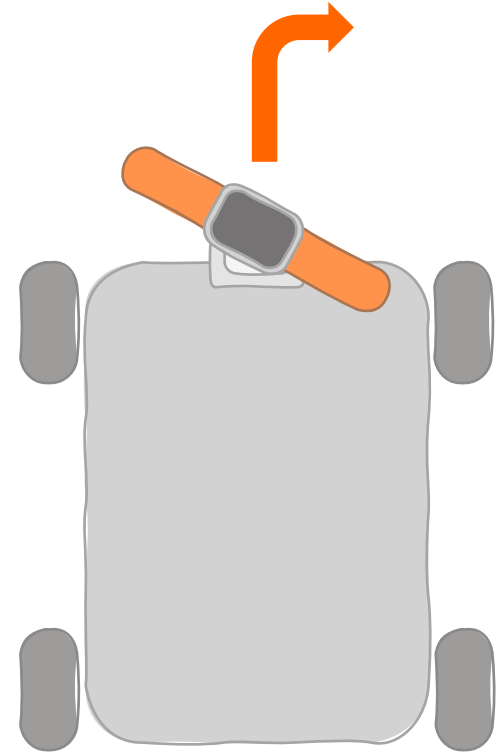
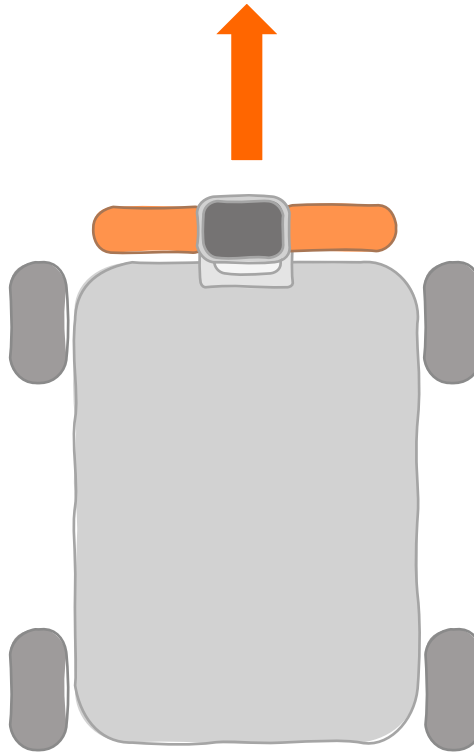
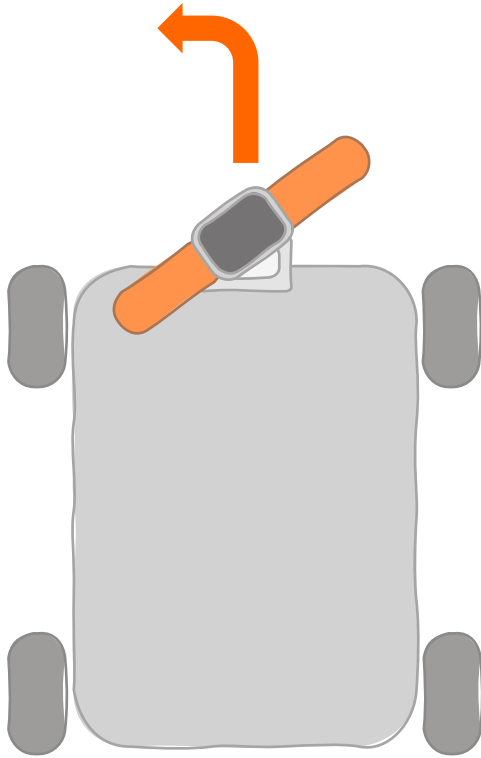
User Journey Mapping

Stage	Action	User Goals	UX Elements Involved	User Feedback
Startup	Press On/Off Button	Power on the scooter	On/Off physical button	Display lights up, showing the home screen
Start Ride	Tap "Start Scooter" on display	Begin riding the scooter	Start Scooter button on display	Transition to in-ride display with speed and battery indicators
During the Ride	Adjust speed using gear buttons	Control speed	Gear Up and Gear Down physical buttons	Display updates gear indicator and speed
During the Ride	Monitor speed and battery status	Stay informed about ride metrics	Speed and battery indicators on display	Constant visual feedback
During the Ride	Press brake lever	Slow down or stop the scooter	Brake lever	Immediate physical response, no change on display
During the Ride	Navigate turns	Steer the scooter	Handlebar	Immediate physical response
Stop Ride	Tap "Stop" on display	End the ride	Stop button on display	Transition back to the home screen
Shutdown	Press On/Off Button	Power off the scooter	On/Off physical button	Display turns off, indicating shutdown
Charging	Connect charger	Recharge the scooter	Charging port	Visual representation of charging status on display
Settings	Access settings menu	Customize ride settings	Gear icon on display	Display shows settings options
Provide Feedback	Fill feedback form	Share user experience	Feedback form in settings	Confirmation message upon submission

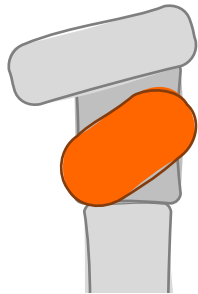
Indicators and Headlights



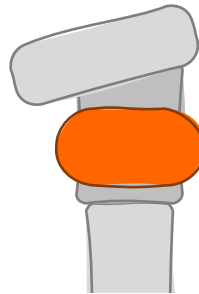
Navigating Interactions



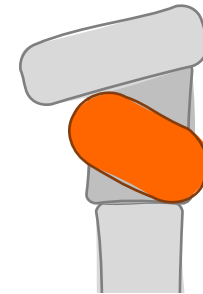
Speed Control Interactions



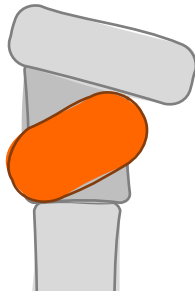
+ Speed



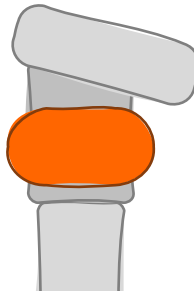
Speed



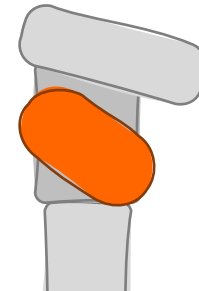
- Speed



+ Speed LVL



Speed LVL



- Speed LVL

Screen Interface and Communication

By integrating the Nextion 3.5-inch Discovery series HMI display with our Arduino Mega, we can develop a sophisticated and user-friendly interface for controlling and monitoring our personal mobility device. This combination of hardware and software design will significantly improve the overall usability and appeal of the vehicle.

Nextion 3.5-inch Discovery Series HMI Display :

Features

1. **Touchscreen Interface:** Allows intuitive user interaction through touch-based controls.
2. **TFT LCD Display:** Provides a vibrant color display with a resolution suitable for graphical user interfaces.
3. **Built-in SD Card Slot:** Enables storage of graphical assets and data for standalone operation.
4. **Programmable with Nextion Editor:** Customizable using the Nextion Editor software, which simplifies interface design and programming.

Functionality

1. **User Interface Design:** Use the Nextion Editor software to design custom graphical interfaces with buttons, sliders, gauges, and text elements.
2. **Touch Control:** Implement touch-sensitive controls to trigger actions or adjust settings directly on the display.
3. **Data Visualization:** Display real-time data such as motor speed, battery status, and sensor readings in graphical or numerical formats.
4. **Feedback Mechanism:** Provide visual feedback to users based on system status, error conditions, or operational modes.
5. **Interactive Elements:** Incorporate interactive elements like menus, pop-ups, and animations to enhance user experience.

User Interface Design

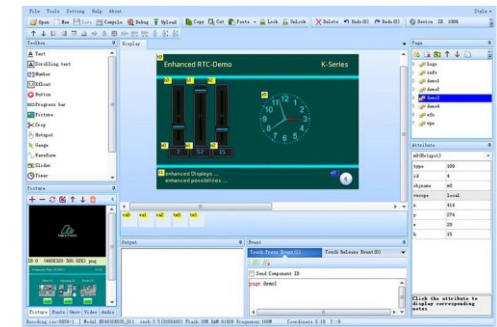
1. **Status Indicators:** Show motor status, battery level, and system alerts.
2. **Control Elements:** Provide intuitive controls for speed adjustment, mode selection, and system configuration.
3. **Visual Feedback:** Use color-coded elements and animations to convey information

effectively.

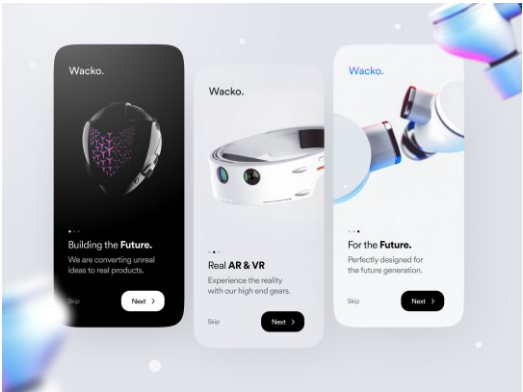
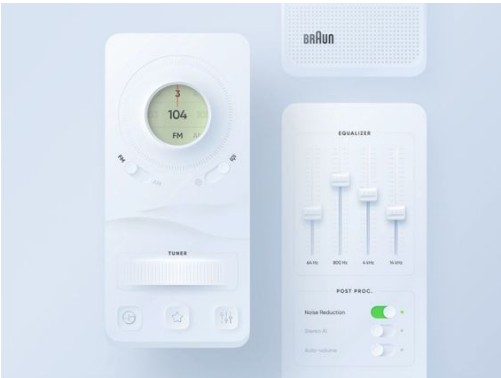
4. **Menu Navigation:** Design a hierarchical menu system for accessing different functions and settings.

Usability Considerations

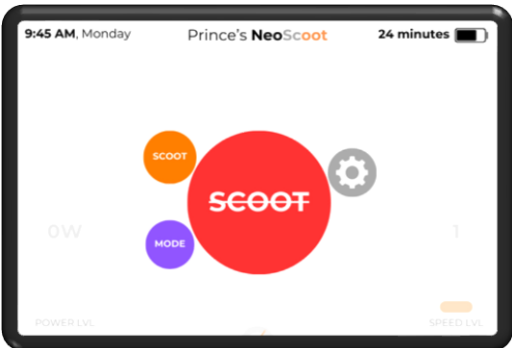
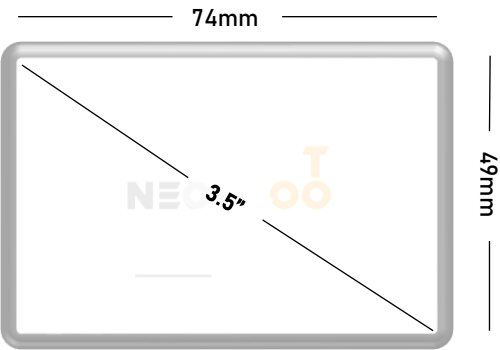
1. **Layout Optimization:** Arrange elements for ergonomic and intuitive interaction, considering the display size and resolution.
2. **Responsive Design:** Ensure responsiveness to touch inputs and adaptability to varying user preferences.
3. **Error Handling:** Implement error messages or prompts to guide users in case of invalid inputs or system faults.



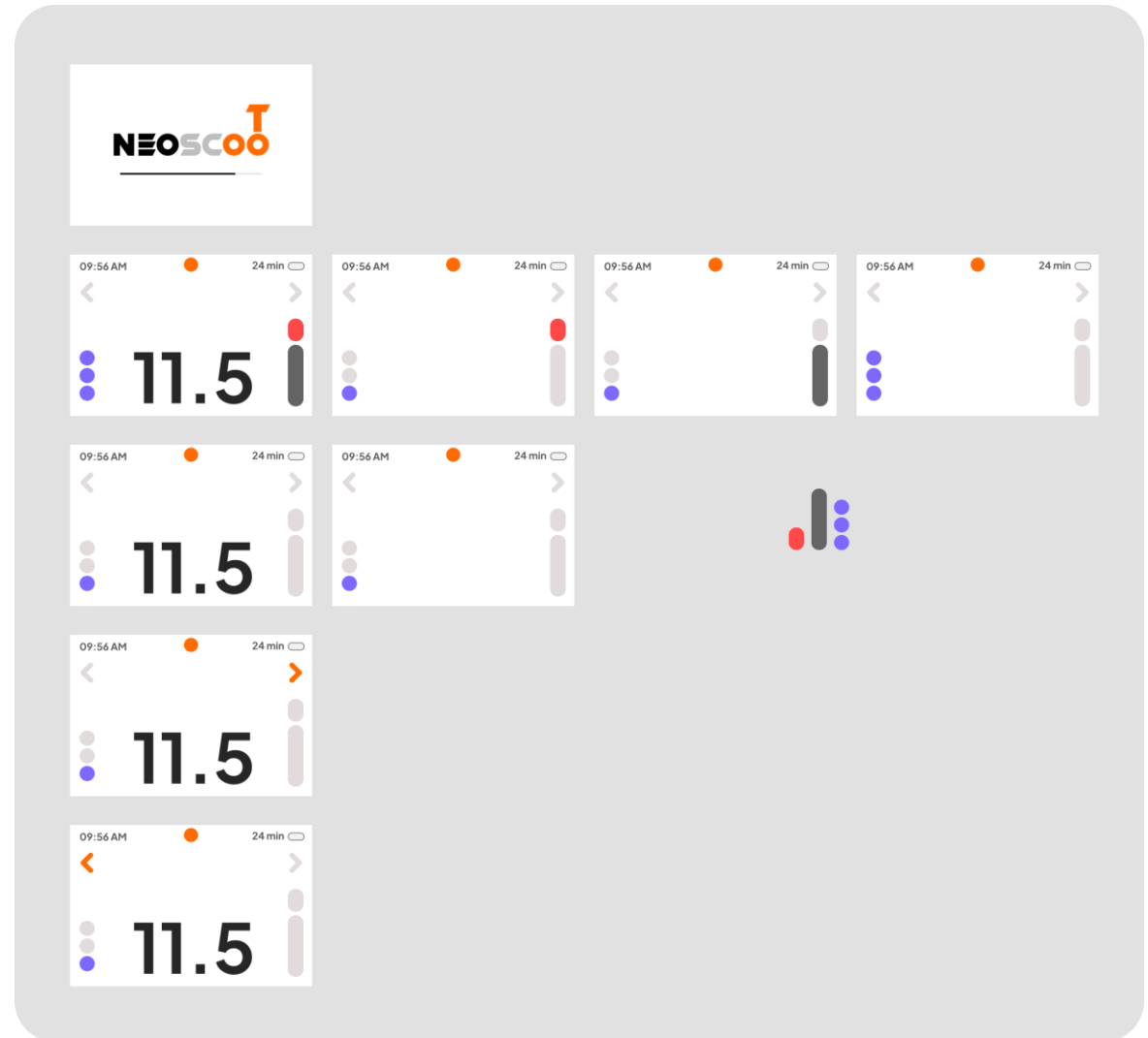
UI Moodboard



PROTOTYPE 1.0



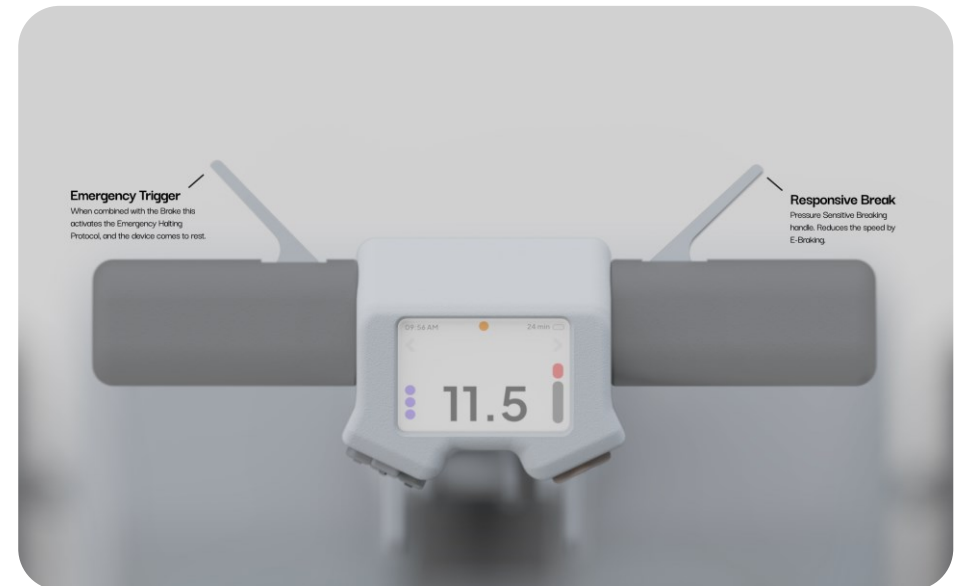
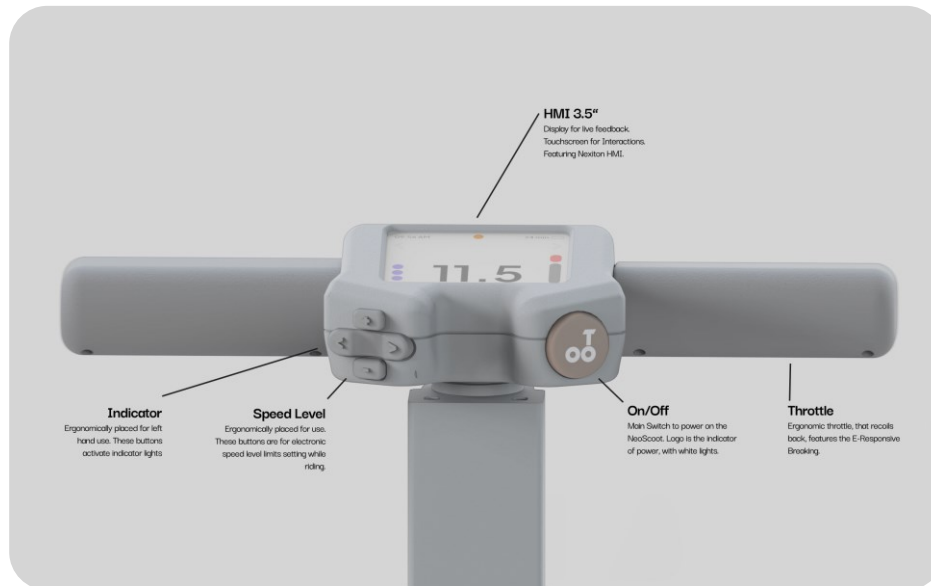
PROTOTYPE 2.0



Interface



Buttons and Brakes



Future Scope

Tactile UX (Physical Interaction)

Physical Controls

Buttons: On/Off, Brake, Gear Up, and Gear Down buttons offer tactile feedback. Each button has a distinct feel and response, allowing users to operate them without needing to look.

Handle Grips: Textured handle grips provide a secure and comfortable hold, improving user control and comfort during the ride.

Surface Materials

Ergonomics: The scooter's surfaces are designed with user comfort in mind, using materials that are pleasant to touch and grip, reducing fatigue during prolonged use.

Haptic Feedback (Touch Feedback)

Vibration Alerts

Status Notifications: Haptic feedback can be used to alert users to critical notifications, such as low battery or over-speed warnings. A slight vibration in the handlebar can inform the user without needing to look at the display.

Confirmation Feedback: When users change gears or engage/disengage the motor, a haptic confirmation can assure them that the action has been successfully registered.

Safety Features

Obstacle Detection: Incorporating haptic feedback for proximity sensors can alert users to nearby obstacles, enhancing safety.

Audio-Visual UX (Auditory and Visual Interaction)

Audio Feedback

Voice Prompts: Audio cues or voice prompts can guide users through different functions and notify them of important information (e.g., "Battery low," "Ready to ride," "Charging complete").

Beep Sounds: Subtle beeps can provide feedback for actions like button presses or notifications of changes in the scooter's status.

Visual UX

Nextion 3.5-inch HMI Display:

Dashboard Interface: The display shows speed, battery charge left, and other critical metrics in a clear, easily readable format.

Interactive Elements: Touch screen interactions for starting/stopping the scooter and navigating settings provide an intuitive user experience.

LED Indicators:

Status Lights: LEDs can indicate power status, charging state, and warnings (e.g., over-speed or low battery) at a glance.

Headlights and Taillights: Integrated lighting not only enhances safety during night rides but also adds to the futuristic aesthetic.

Interface Design: Clear Icons and Text: The display interface uses large, easy-to-understand icons and text to ensure all users can quickly comprehend the information.

Color Coding: Use of colors to signify different statuses (e.g., green for ready, red for alerts) helps in quick identification of the scooter's condition.

Integration of Multi-Sensory UX

Enhanced User Experience:

Combination of Feedbacks: Using tactile, haptic, and audio-visual feedback together can create a rich, multi-sensory user experience. For example, a button press can be accompanied by a small vibration and a beep, reinforcing the action's success.

Accessibility: Multi-sensory feedback ensures that users with different preferences and needs (e.g., visual impairments) can effectively use the scooter.

Safety and Efficiency

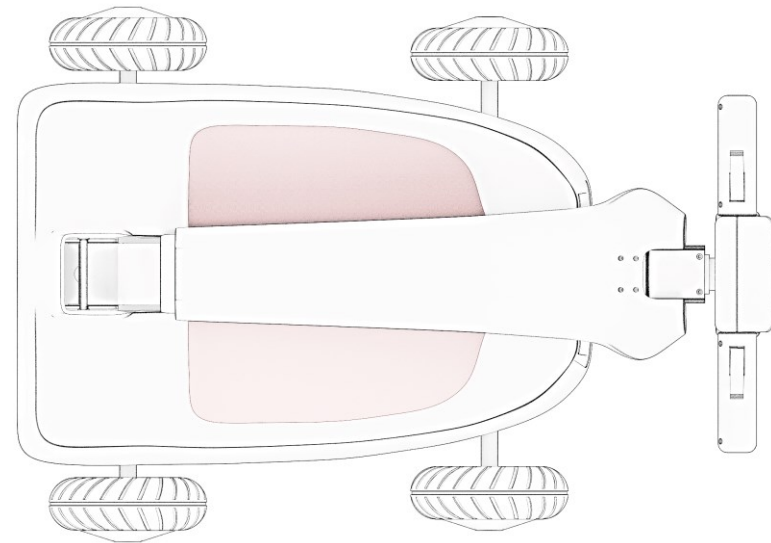
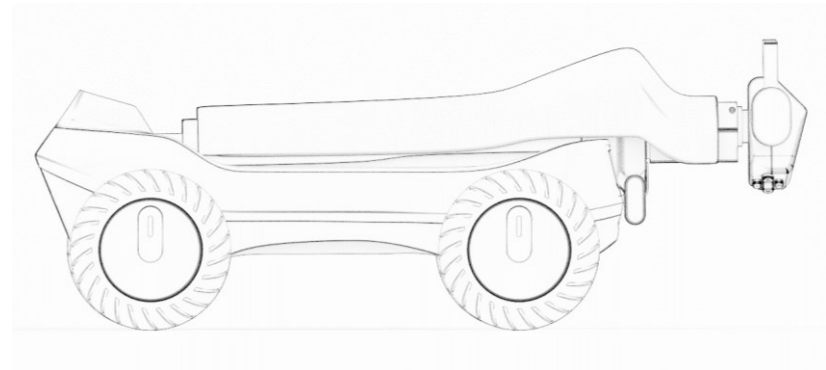
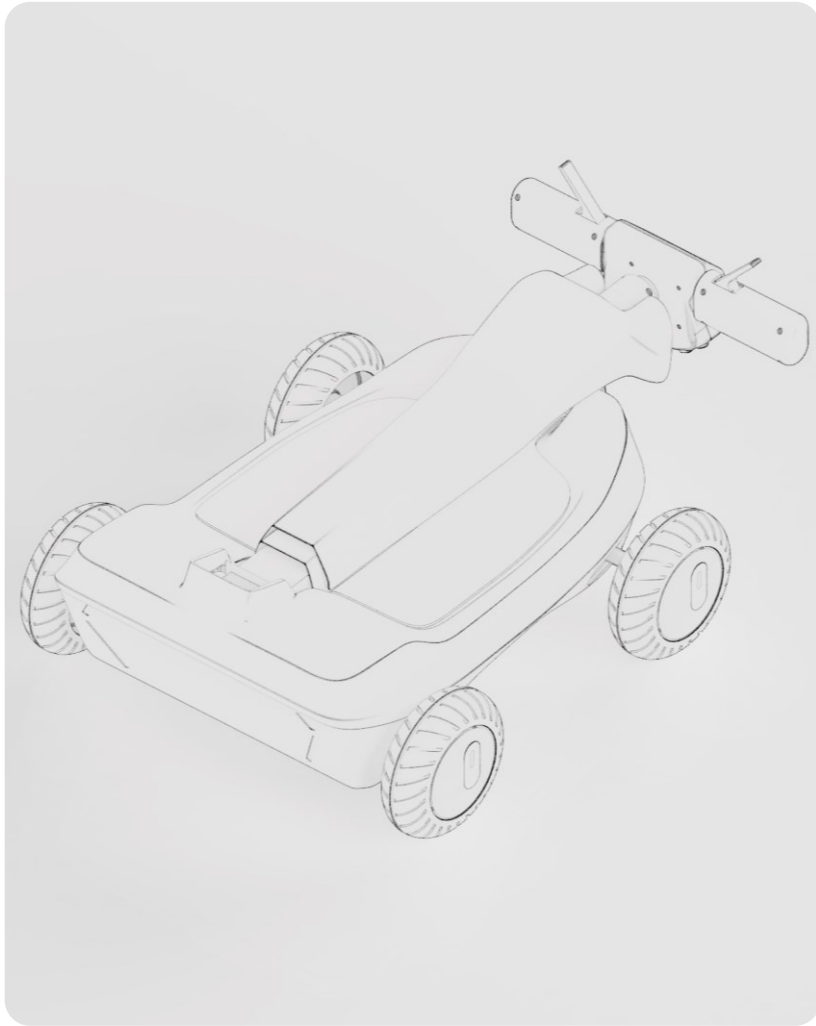
Immediate Alerts: Combining haptic feedback with visual and auditory alerts can ensure immediate user attention to critical warnings, improving safety.

Guided Navigation: Audio-visual instructions can guide users through complex functions or troubleshooting, reducing the learning curve and enhancing overall usability.

PRODUCT DETAILING

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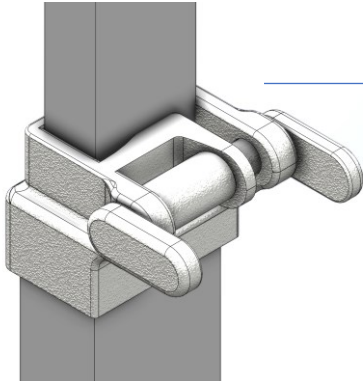
Folding Mechanism



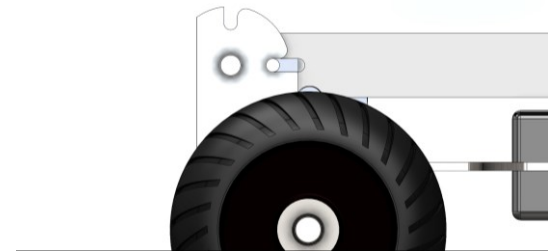
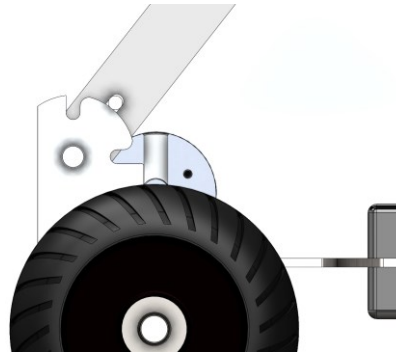
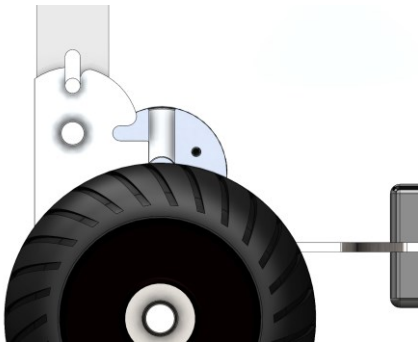
Folding Mechanism



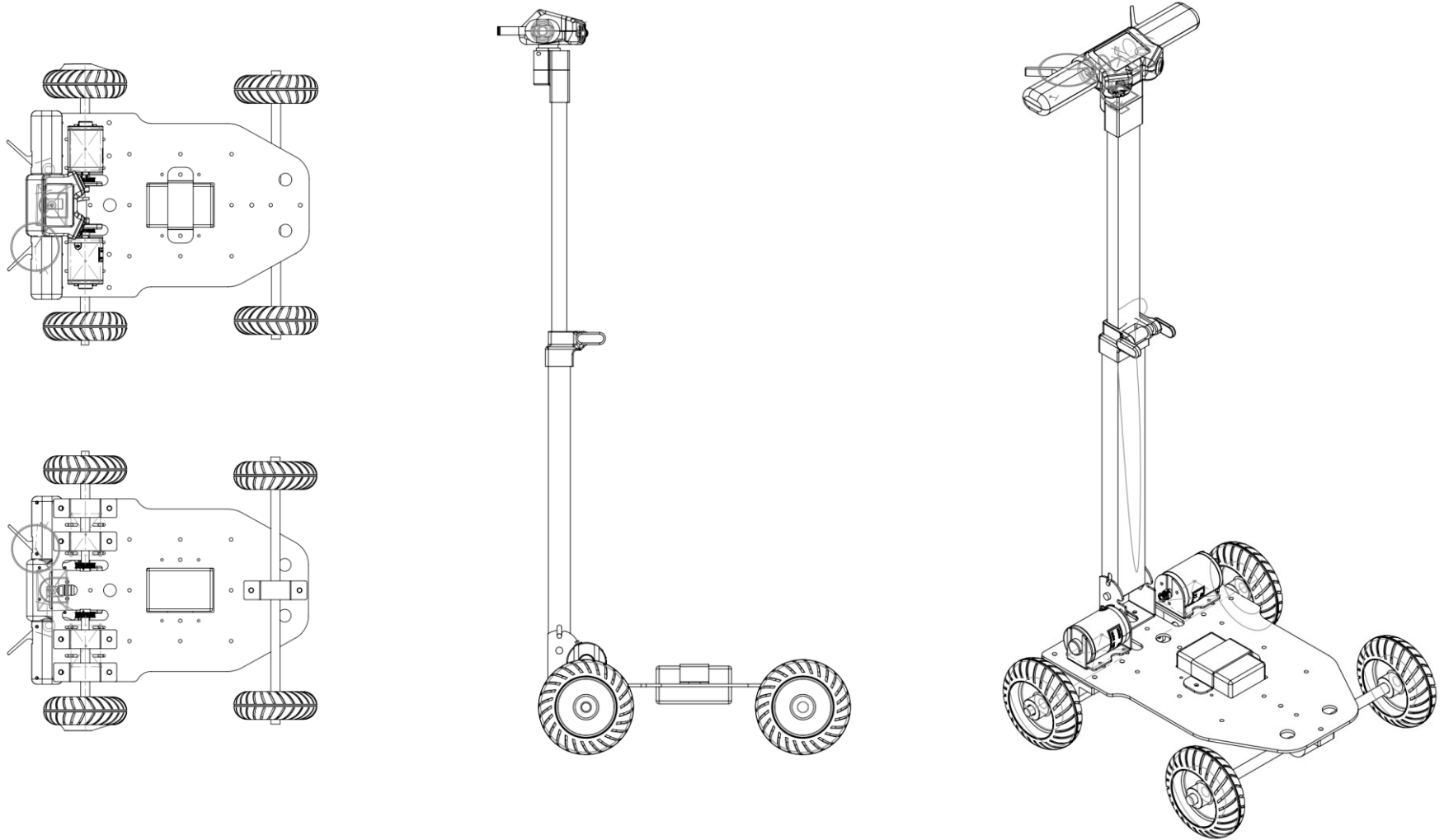
Locking Mechanism



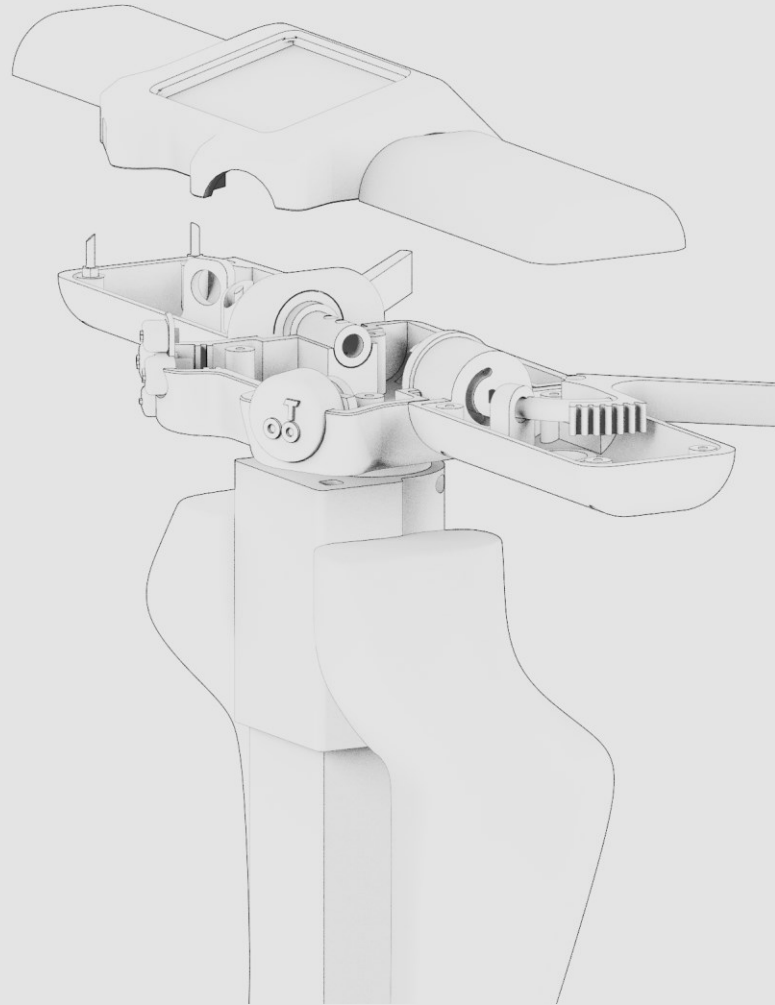
This is a complaint mechanism, where which the flap pushes the telescopic channel and locks it.



Mechanical Detailing



Plastic Detailing



PRODUCT VISUALISATION

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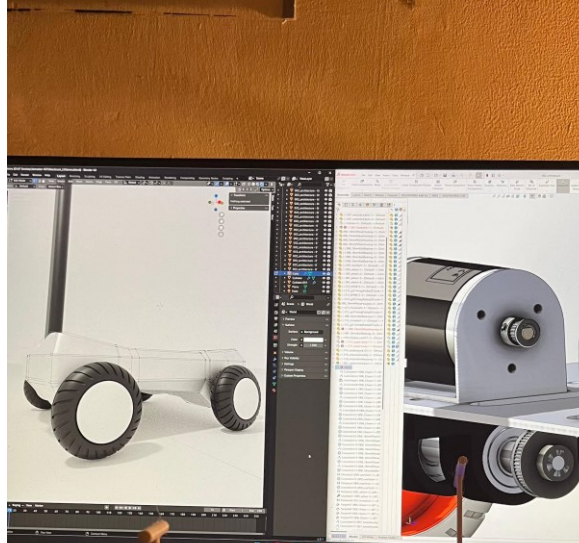
FINISHING & PROTOTYPING

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Fabrication of Final Prototype



Fabrication of Final Prototype



Fabrication of Final Prototype



Fabrication of Final Prototype



Fabrication of Final Prototype



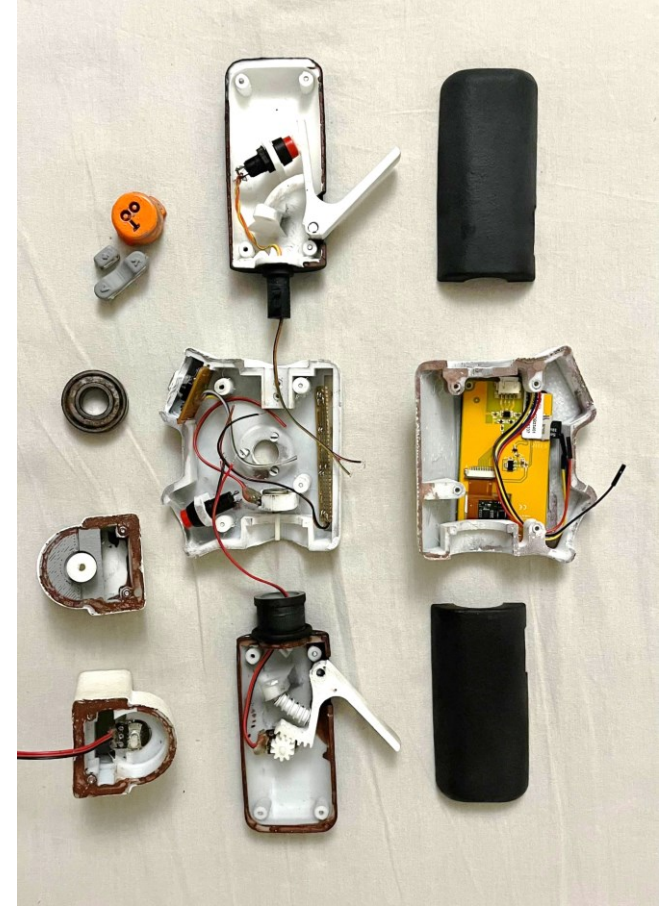
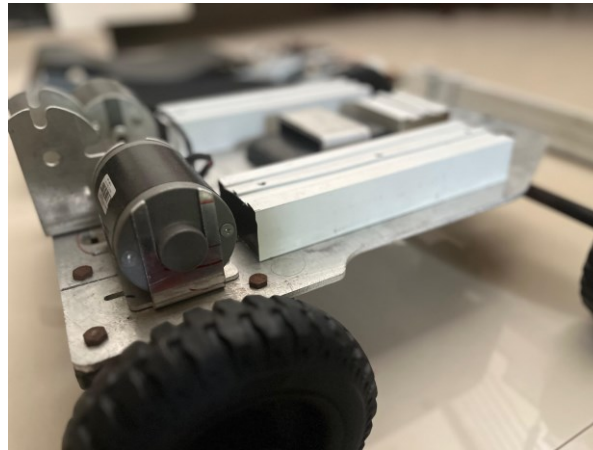
Fabrication of Final Prototype



Fabrication of Final Prototype



Fabrication of Final Prototype



CONCLUSION

21

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