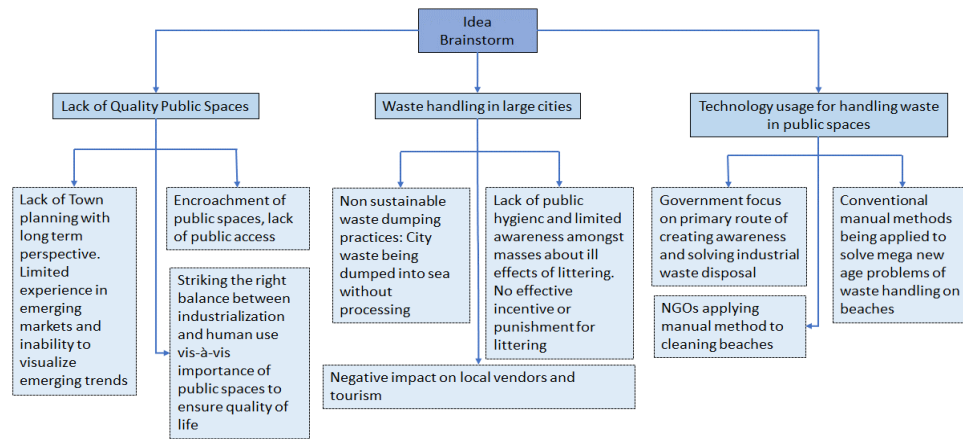


CRITERION A: INQUIRING AND ANALYSING

Ai (Design Need): Explain and justify the need for a solution to a problem for a specified client/target audience

Brainstorming Ideas (Situations and Problems):

Decoding the unit plan, I identified 3 different situations prevalent in today's world that I relate with or have noticed in my daily life.



personal connect (how close the problem is to me), and the urgency to create a solution, to work with in order to start creating a solution. According to my personal connection and the results, the problem of large- scale wastes on beaches requires an effective solution on an urgent basis using new age advanced robotics and autonomous vehicle technology.

Furthermore, I identified a few problems for each of the situations. Finally, I identified one of the problems based on the

Design Situation: Currently in Mumbai there are a lot of beaches, but those beaches unfortunately have a lot of trash. In Mumbai alone there are up to 30 to 70 tons of trash which get collected daily. This is due to lack of awareness among citizens and less trash cans. As a result, fewer tourists are visiting beaches harming tourism. According to various research papers, cleaner beaches can attract significantly more tourists than normal. In the city of Mumbai most of the beaches also are extremely uneven hence playing sports is challenging. In many beaches there are several different NGOs trying to support beach cleanup, however due to the excessive amount of waste they are unable to reach their goal

Problem: Due to the problem of waste handling on beaches local businesses are harmed and several research papers have shown dirty beaches tend to repel tourism making it difficult for street vendors to make profits. It is difficult to gather such a large number of volunteers causing a lot of problems for NGOS. Many new NGOS face this issue and as a result of this they aren't able to achieve their full capacity. A lot of beach clean-up equipment such as

Goal	My goal is to address the challenges associated with collecting and disposal of beach waste/trash. I have decided to make a device which is automatically able to help clean the beaches without any human intervention. Currently in Mumbai there is a lot of trash which makes it difficult for local vendors to be able to provide for their family. Dirty beaches can drive down tourism by 60% tremendously affecting the local vendors. Unhealthy amounts of trash present can also cause health problems for local vendors who have to sit on beaches the whole day, and due to lower sales the vendors may not be able to afford medication. These unhygienic amounts of trash also affects volunteers working manually impacting their health.
Role	I have collaborated on research to define design problems and develop a design brief. I have provided and obtained feedback throughout the design process. My role is to develop feasible designs that solve the design problem. I have utilised feedback from peers to iterate and improve my designs. My role as a designer is to consider the ethical, environmental and social impact of design. I am looking to maximize the positive impact of my design.
Audience	The product is primarily designed for the benefit of local businesses and NGOs who are impacted by beach trash and current practice of manually cleaning it. The product is expected to invoke curiosity of designers, local governments, activists and entrepreneurs. The operator of the product should be from 18 to 60 years old. Any operator below 18 may not understand electronics and circuits fully, hence not being able to take care of the device and any operator above 60 may not have the physic to run after the device and fix a problem that may occur.
Situation	I am designing a prototype that solves the design problem involving building autonomous vehicles to clear beach trash. The design is focused to address the social elements impacted by the beach trash problem.
Product	The key product goal is a prototype of an autonomous vehicle ¹ , which is able to identify, segregate, collect and dispose of beach trash. The product

¹ An autonomous vehicle is one that can drive itself from a starting point to a predetermined destination in "autopilot" mode using various in-vehicle technologies and sensors, including adaptive cruise control, active steering (steer by wire), anti-lock braking systems (brake by wire), GPS navigation technology, lasers and radar. The 4 Pillars of autonomous vehicles are Perception, Localization, Planning, and Control. It all starts with Perception, which is about "seeing", and the data is then passed to localization, to trajectory planning, and finally to controllers.

rollers can be also expensive. Even after being able to afford such equipment, it is difficult to fully clean all the beaches. In Mumbai alone there are 44 beaches with some beaches even being up to 6 km long.

	should meet the design success criteria identified during research and planning stage
Standard	The device I am making for the clean up needs to have high standards as the product is automatic and any deflection can harm the beach instead of cleaning it. The parts in my product should be of the highest quality, the product should also be able to pick up 90% to 95% of the trash it encounters. If materials of high quality aren't used the automobile device may end up in the ocean causing severe damage to life under water destroying the whole purpose.

Target Audience: My primary audience are beach clean up NGOS and local businesses in the area. There are around 10 to 20 beach clean up NGOS in Mumbai with each NGO having an average of 100 volunteers, most of these NGOS operate on a weekly basis. In Mumbai alone once a week over 215 volunteers gather for beach clean ups trying to achieve the STG goal of 'Life on land', however due to time constraints and too much area they aren't fully able to achieve their goal. If automobile devices can be made which do the same job it would help the NGOS tremendously. Having such a device would also help the local business a lot, despite there being such a great amount of volunteers they still aren't able to cope up with the constant trash. Many areas are missed while cleaning up which repels tourists.

Need for Solution: The goal of my product is to (a) help in beach clean-up; (b) work in such a manner that makes it not only easier to clean beaches but also convenient for the NGOS.

- *Need for beach clean-up:* In cities like Mumbai there are many beaches which are filled to the brim with trash. This trash keeps getting piled up, harming the environment. To empower the SDG goals of 'Climate Action' and 'Life on Land' beach clean ups are essential. Climate change talks about recycling, reusing and composting our waste in a responsible manner. Currently there is a lot of plastic, paper, etc present on beaches. These are different categories of waste and need to be disposed of in a different manner. However if these wastes aren't disposed properly they will not only harm the environment but also the life on beaches. Beaches are the home to many animals like crabs, snails, etc. If this waste is not disposed of they will gather on top of their home causing injustice to the animals. Due to so much trash, tourists are also not inclined to visit the beach harming the 2.5 lakhs local business present in beaches. Most of these beaches the sand is also very uneven leading to foundation issues, less pleasing to the eye and also sports like volleyball and cricket need flat land.
- *Technology driven solution:* The quantum of trash, recurring nature of its occurrence with high tide and regular dumping by beach visitors/vendors, geographical landscape of large open area makes it practically difficult to clean-up manually. To solve this problem my product aims to pick up trash with the help of automobiles.

Possible Solutions: Prototype of final product, being an autonomous vehicle should solve for:

- Pick up wastage and make beaches studier
- Work and collect trash without any human interaction
- Not disturb, hurt or get hurt by anyone
- Dump all the collected trash into one location
- Aim to make the sand even as it picks up the trash

The product will:

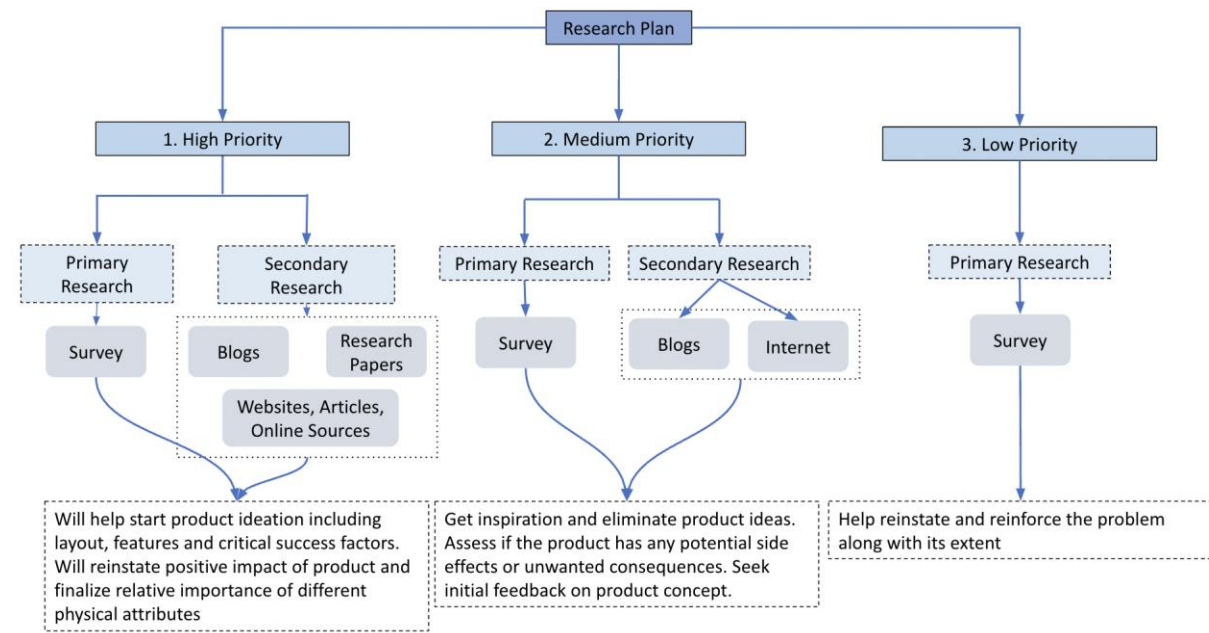
- Use innovative technology to help existing local vendors in the area
- Connect the product with the RC as innovation is being used to help local markets.

- Have a variety of different sensors and components to achieve its goal of cleaner beaches making products related to KC

Connection with the Unit Plan

<i>Global Context:</i> Identities and Relationships	<i>Key Concept:</i> Systems	<i>Related Concept:</i> Evaluation, Innovation, Markets & Trends	<i>Statement of Inquiry:</i> New technologies impact the way people live, work, and play
The design problem is closely related to global context as it focuses on how to build a healthy physical relationship between environment and technology that impacts psychological and lifestyle choice for the society. The product will help in improved physical wellbeing as cleaner beaches increase hygiene and encourage society's to spend time with nature. The product will attract tourists to the beach changing psychological state.	The design problem talks about the need to have a System which incorporates technological evolution to find efficient solutions to modern day societal problems. A System can be referred to as an arrangement where different things interact to create a homogenous effect.	The design problem uses best design principles from existing products in the market and applies innovation to develop a simple yet effective solution. Markets trends are thoroughly evaluated before design finalization	The design problem connects to the statement of inquiry because if a product could be created incorporating newer technologies in robotics and autonomous vehicles and will save humans time, effort and costs that directly affects lives, work and play of a section of society. Moreover, if the design of the product is efficient enough, incorporate new technologies in a cost effective manner.

Aii (Research Plan): Identify and prioritize primary and secondary research needed to develop a solution to the problem



Research Questions

Inquiry Questions	Why do I need an answer?	Priority & Source	Relevance & Justification for Priority
Which sensors could be used while creating a product to make it go in a straight line?	Sensors are a crucial part of making any automated device. Having the correct sensors can transform the whole product drastically. For example, to make my product go in a straight line, choosing the correct sensor is very crucial. If the correct sensor is chosen then the product will be able to easily cover the area it is supposed to and return to its original position, however if the wrong sensor is used then the product may end up drifting and going inside the ocean.	Secondary Research, High Priority	Finalize the use of sensors which if one of the critical success factor for the product
Which safety features should be in a beach cleaning automated device?	Safety features in any product is always a top priority and needs to be handled with the utmost care. Without proper safety features the product could be dangerous to operate and made illegal to use. A lack of safety precautions could also harm or seriously injure the pedestrians on the beach.	Secondary Research, High Priority	This will help me start with the product idea and lay out its foundation plan.
What is the ideal power that will be needed to power an automated device?	After knowing the distance the device will have to cover, it is also important to get to know the ideal power which will be needed. According to the power which can be provided the usage of certain parts and components will also be decided. For example if a sensor takes more power that can be provided to it then the sensor will be of no use and different components will have to be used.	Secondary Research, High Priority	Help determine whether a solution I aim to create will be impactful or not
To what extent will cleaner beaches help your business/NGO and why is that?	This is arguably one of the most important questions to understand the purpose of the product. The answer to these questions will help me understand on a local and personal scale if the problem really exists and the depth of the problem.	Primary Research, High Priority	This will help identify possible positive impacts of cleaner beaches for local businesses
How much area would you want one device to cover in the span of one battery life?	As a designer it is really important for me to know the total output the clients are expecting out of the product that can work according to those specifications. If my clients are expecting that the range be really long then weight, speed, battery life, etc will need to be adjusted accordingly.	Primary Research, High Priority	This will help me assess the relative importance of different physical properties of devices. This will finally help me finalise the fundamentals of the solution.
What physical components could be used while creating such a device for optimal usage?	When it is time for the physical creation of the product it will be extremely important to know which parts are to be used where. Regardless of the code or the sensors used, if the physical parts are not up to the mark or don't fit with the components then the product will not be able to function.	Secondary Research, Medium Priority	Finalize the features of the solution only after analysing the problem.
Would there be anything specific you would want in the product (looks, speed, capacity, size, weight, etc)?	Knowing what the users want from the product is a crucial part for user satisfaction and product optimization. The clients have been in the beaches for way longer than I have as a designer, due to this they possess more knowledge about beach clean ups and their advice could help boost many factors such as function, aesthetics, etc for the product.	Primary Research, Medium Priority	Get inspiration, and eliminate competition by ideating. Understand if the basic goal of my solution sounds helpful to the audience and if my solution will be beneficial.
What is the ideal capacity the device should have to pick up trash and how fast should the	It is crucial for me to know the expectancy of trash my clients expect my device to be able to pick up. Understanding the client's expectations is a crucial step to make the final product successful. The product size, efficiency and power will be based on this answer.	Primary Research, Medium Priority	This will help me analyse if there are preexisting similar products and their limitations/strengths.

Inquiry Questions	Why do I need an answer?	Priority & Source	Relevance & Justification for Priority
device be able to pick up trash?			
How can the automated device avoid humans and clean the beach in a sophisticated manner?	Avoiding obstacles such as humans is not only crucial for human safety but also for optimal usage safety of the device itself. If the device hits a human not only will the human get severely injured, but the device may also break if it repeatedly comes near the human. Someone may step or flip the automated device putting it out of use until a human flips it back or even completely breaks the device.	Primary Research, Medium Priority	This will help me understand whether all the stakeholder benefit from the product
What is the most challenging part while picking up the trash and how will an automobile device be able to improve this?	Knowing the challenges which humans face while picking up waste can help me as a designer to make this device. For example if humans have difficulty bending down each time they want to pick up the waste the device could be made at a ground level so it doesn't have to bend.	Primary Research, Medium Priority	This will help reinstate and reinforce the problem along with its extent.
To what extent does the sustainability of the actual product matter to you?	It is important for me to know how much certain aspects of the product matter to my client. The product I am making wants to achieve the UN goal of Climate actions, which is directly linked to sustainability, hence my clients may think having a sustainable product is very important to fully achieve this goal. However, in my opinion, to optimize the usage of the product, non sustainable materials are necessary.	Primary Research, Low Priority	This will help me understand if my solution has the potential side effects or unwanted consequences.

The most important results of research performed in Strand 1 and Strand 2 are:

- Research reconfirmed the need for an autonomous vehicle which facility cleaning-up of beach trash
- The autonomous vehicle will not only save human time and labour involved in beach clean, can also do the task on regular basis with very high degree of efficiency
- The vehicle should be simple of operate with high performance battery life and ability to handle meaningful volume of trash. The vehicle to be safe both in terms of its technical features to avoid break-down, but also eliminate possibility of causing accidents for visitors while performing its functions
- Aesthetics and speed are good to have, but need to balances with cost and overall product design

Aiii (Existing Products) Analyse a range of existing products that inspire a solution to the problem

SWOT Analysis of Comparable Products

Description	 The Serial Cleaners	 Classic Product	 Basic robot with Gyro sensor
Image			
Product	“The Serial Cleaners” is developed by Poralu Marine. The aim of this product was two-fold, this product aims to clean every trash piece from the beach and also make the beaches flatter.	This is a classic product manufactured by many companies around the world. This product is only used to pick up trash and has to be operated manually.	This is a basic robot which uses a gyro sensor to make it go in a straight line. This product is able to remain in a straight line even when it is pushed outside of its path.
Strength	This product has great agility, it is able to maneuver around obstacles providing easy to use, this bot has a trash storage capacity of 100 liters proving a lot of space for trash to be stored and can pick up a lot of trash at once. This robot is fully electric and also solar paneled, this allows the robot to not only operate for longer periods of time but also the robot becomes sustainable. It has emergency stop buttons, safety lights for visibility and warning sounds for alert. The range of the robot is 150 meters providing a great distance and the robot is able to move without disconnecting. This robot is not only able to operate on sand but due to the lifting back part the robot can also operate on concrete roads.	This product is extremely light, compact and easy to carry. Due to these features this can easily be carried around the beaches. This product is extremely cheap with some of these being as cheap at 415 rupees or \$5. As a result many NGOs who are in their starting stage, easily buy and use many of these products. Additionally this product is height adjustable making it easy for anyone to use. As this product is attached to an adjustable stick while picking up the trash, bending down is not required. One of the main problems while picking up trash is back pain as bending down constantly is required. This product also has a strainer type design which allows the product to pick up trash while avoiding the sand. It can also be used in any weather and temperature. Lastly this product has wheels attached to it due to which the product is able to move and maneuver through the sand easily. This product has small holes in its tyres so the sand doesn't get stuck and easily comes out.	This robot is extremely compact and small in size. This device is also able to go in a straight line without any external requirements. Due to the gyro sensor used in this product it is able to maintain its path in uneven surfaces when moved by external forces. Due to the big wheels used in this product it is easily able to go through big surfaces without any trouble. The size of the wheels also impact the speed of the robot making it faster than normal. On the top of the robot there is a lcd screen display. This display allows the robot to convey important messages to the user without needing any external source. This product is also able to work autonomously due to the pre-programmed code and the high quality physical components. This product also has fewer parts compared to the other components creating less rattle and the device more durable.
Weakness	Due to the giant size of this robot there are a lot of problems which may happen. The total battery life of this robot is only 3 hours when solar panels are not being used. As a result this product always needs to be used during daylight making it inconvenient for tourists wanting to visit the beach. Due to the	This is a manual product with no automation. For this product to work successfully a human needs to walk around the beach with the product in their hand. This is extremely time consuming and hectic. If someone is being hired to clean the beach using this product the price of labor quickly starts to add up. The waste	The product only has two working wheels, the third wheel is a caster wheel and has no motor attached to it. Due to this if the robot ever gets stuck in a muddy or uneven surface despite the 2 main wheels being big and powerful the robot won't be able to escape the surface. The electronics of the robot are also very open with nothing to cover it,

Description	 The Serial Cleaners	 Classic Product	 Basic robot with Gyro sensor
	excessive amount of motors present on the body there is a lot of noise pollution which disrupts the calm environment usually present on beaches and disturbs the tourists. This product has to be controlled by a human. There has to be a human in charge who operates the robot, making it very expensive and time consuming. The robot itself cost \$55,000, this exudes the daily maintenance price. The range of the robot is only 150 meters, a beach is usually 1 to 2 kms with some going up to 6 kms in Mumbai alone. The operators of this product will have to move around with the robot causing inconvenience.	storage capacity in the robot is also only 5 liters. This calls for frequent trips back to the waste storage facility denying users to be able to cover larger areas. This product can't be operational in the dark as a human is needed to operate the product and the beaches can be difficult to navigate in the dark. This product also has no inbuilt light or sound so the product becomes inoperational at night. Additionally, this product is only able to pick up trash and not flatten beaches.	as a result dust or rain particles could easily corrupt the electronics of the robot. By the looks of it the wheels of the robot also look very thin and low quality which can cause the robot to easily flip over from gusts of wind and it won't be able to handle rough terrain. This robot is also made out of plastic lego pieces, these pieces are not meant to handle tremendous pressure and load making the robot weak despite it having fewer and lighter parts than other robots. The battery life of the robot is also minimum with it only being 30 minutes. This is because the part which is acting like the motors, arduino and sensor is also the part in which the battery is there. Due to this the battery life is severely impacted due to this being such a simple robot.
Opportunities	As a result of the solar paneling in the robot this device could operate in remote areas with minimal power supply. This robot could be placed in a sunny robot that can charge fully within a matter of hours. The charging will be very effective due to beaches being a naturally sunny spot. This product could also be used on different surfaces such as dirt, concrete, etc. This will be possible due to the tyre belts. In beaches if cameras are placed on the device it could be used as a patrolling device around the beach. After adding cameras if the bottom half which is the trash picking half is removed then this robot could help explore new parts of the beach. Lastly due to the beach flattening ability this device could build a sports ground for sports such as football, volleyball court and even cricket pitches. The robot could flatten and clean the grounds on a daily basis.	Due to the extremely simple and rough design of this product it can be used in different plan surfaces such as dirt, soil, etc to pick up trash. This product can also be on almost any surface and the wheels will be able to keep up. If weight rollers are attached to the bottom of the product then the product will not only be able to clean beaches but also flatten them. The product can also be attached behind remote controled or an autonomous device and the device will become a trash picking robot at an extremely cheap cost. If a product is extended a bit and a larger trash bag is attached to the back of the device then the device will be able to easily collect sand without any trash. This product can be used in very bushy areas such as the outskirts of a jungle of even plants to pick up leaves. This product will be able to pick up fallen leaves and even blades of grass which have fallen down. With a little modification this product can be used while dog walking to pick up the dog waste. If the product is made on a solid surface with no holes then a transformation like this is possible.	This device could be used for a lot of different activities and these include. <i>Household cleaning:</i> If a vacuum or a simple broom stick is attached to the bottom of the robot and a simple house map is given the robot will be able to clean the house accurately better than most clean bots due to the high quality sensors used in the robot. <i>Beach clean up:</i> If stronger motors, a better quality of wheels and a simple trash picking net is put on the robots nose then the robot will autonomously be able to pick up a lot of trash even during the night, this is a feature which is not present in even high quality beach cleaning robots which can cost up to \$55,000. <i>Food catering:</i> Nowadays many restaurants have started keeping robot to give the food to their customers instead of waiters, this robot could do a excellent job, this device is able to go in a straight line at a constant speed , doesn't make too much noise and also has a LDR display screen to greet and talk to the customer. To make this robot even better a cup holder and extended trays to keep plates and cups could be added. <i>Material transportation:</i> As this is a lego robot and can be built on easily, if there were more battery pack attached, 2 more wheels, 2 more motors and a larger surface area this robot could also be used to transport materials such as wooden logs and metal poles in a construction site. Due to the precision sensors in this robot it will not divert

Description	 The Serial Cleaners	 Classic Product	 Basic robot with Gyro sensor
			from its track despite the uneven weight distribution.
Threats	This product has a lot of problems it could face under a variety of different circumstances. None of the videos or photos show the working of this robot under unpleasant conditions. If it suddenly starts to rain or a storm emerges this robot will shut down completely. Storms and rains are when most of the trash is present and the shutting of the robot at that time can be problematic. This robot is also manually controlled with only a range of 150 meters. If the person controlling the robot gets distracted the robot can easily deviate from its path and end up in the ocean or worse and harm many visitors on the beach. This can also happen if the robot gets out of range. One more caveat is if the battery runs out and there is no sun to charge the bot it will be stuck there with no definite solution.	The whole body of the product is made out of metal. Metal can easily get hot, burning some of the trash it picks up and making it extremely difficult to hold the handle of the product. Rolling over the bumpy sand can damage some of the parts in this product. As some of the parts are only held together by a couple of screws and bolts they can easily come out. If the user of the product is not careful they can easily hit someone with the long stick of the product. Visitors may be seated near the cleaning area causing them inconvenience. This product can easily run over sea animals like crabs and snails as there is no preventive measure. Lastly if this product falls inside a hole it will be extremely difficult to remove it due to the already heavy metal the product is made out of and additional the trash which is inside the product further increasing its weight.	This robot only has the gyro sensor and this robot is supposed to work autonomously. This can be a major safety hazard not only to humans but the robot itself. The robot can easily bang/fall/collide/hit/run over, etc to objects. This can easily hurt humans but even break the whole robot. Due to the thin wheels and no external sensor if the robot flips or falls from a height it will break into pieces. As the robot has no external body or protection layer the central brain of the robot which has the motors, sensors and even arduino can get fried very easily ruining the whole robot. If taken a closer look the open wires can easily be seen, this can cause major safety hazards. Loose wires can easily electrify humans causing major injury. If any sand grain or dirt gets stuck inside the wires major problems will be caused and also in unpleasant weather conditions such as rain and storms just by a few drops of water the whole circuit will get ruined. The buttons on top of the robot are also open with no cover. Anyone can click these buttons or they can accidentally get clicked disturbing the whole pre-programmed code given to the robot.

Key Takeaways

#	Product	Key Takeaways (Functionalities and Features)	Key Takeaways
1.	“The Serial Cleaners” is developed by Poralu Marine. The aim of this product was two-fold, this product aims to clean every trash piece from the beach and also make the beaches flatter.	The price of the product should be affordable for the target audience to be able to buy the product. The product should be visible for tourists' safety. The product should be able to navigate rough terrain.	- It is beneficial to a simple product with minimal buttons / switches. - The product should be able to move on uneven surfaces, powerful sensors and power/battery efficiency. - The product should be made of strong and sturdy material, with the ability to operate in adverse weather conditions. Aesthetics and light weight are secondary features for the product
2.	This is a classic product manufactured by many companies around the world. This product is only used to pick up trash and has to be operated manually.	The product should be automated. The product should have a decent trash storage capacity. The product should be multipurpose and be able to flatten the beach.	
3.	This is a basic robot which uses a gyro sensor to make it go in a straight line. This product is able to remain in a straight line even when it is pushed outside of its path.	The product should be able to go in a straight line even if pushed away. The product should have all its wiring secure. The product should be	

#	Product	Key Takeaways (Functionalities and Features)	Key Takeaways
		closed and not expose too much of its circuit.	

Aiv (Design Brief) Analyse a range of existing products that inspire a solution to the problem

Summary of Secondary Research: Beach wastage is a serious problem faced by many people all over India. In Mumbai alone there are 44 beaches with some even going up to 6 kms, this affects not only *beach clean up NGOS but also local vendors*. Currently there are around *2,240 tons* of trash present on the beach causing tremendous problems to beach clean ups and local business. To help in cleaning all this trash on a *daily basis 215 volunteers work*, with no permanent result.

Summary of Primary Research: Interview with Client and Survey with Target Audience: To make this product successful I have conducted a survey with local business and NGOs to understand the users perspective of the product.

- *Local Businesses:* All the clients say that excessive *amounts of trash* affects their business as fewer tourists want to visit.
- *NGOS:* are impacted as they have to hire more volunteers to clean the dirtier beaches *increasing cost* in short term as well as long term. Having an automated beach cleaning device will decrease the need for manual labor.
- *Product features:* The product should also be of *medium pace, a bright color so it stands out and a decent trash carrying capacity*. The robot should be *water, dust and heat proof*. When working in extreme conditions such as beaches excessive heat, rains and dust is common, and as the device is automated it should be able to handle these conditions for optimal usage whenever and wherever the user wants. The clients also expect the product to cover at least *200 meters and go up to 500 meters*. If the device is able to travel such great distances with the trash storage capacity then only *5 to 10 devices* will be able to clean entire beaches in less than a couple of hours. The device should be able to have around *25 liters*, the device should be able to operate at least *30 minutes* with the trash capacity. This will allow the device to cover the distance it is needed to without limitations on the trash storage capacity.
- *Sustainability:* My clients *don't care much about the sustainability* of the product, my clients believe it will be more beneficial if the product is less sustainable in the short term but able to make the world more sustainable in the long term.

Analysis of Existing Products, Design Inspiration and Product Outline: After analysing 3 products which are completely different from each other but each which will help me while making my final product here are my final findings.

- *Trash handling:* The product should have a good trash storage capacity. If there is no place to store the waste after it has been collected the extra battery life, high speed motors, etc will go to waste. Having extra storage space can differentiate a product which is able to effectively clean beaches from a product which is a show piece which is never purposefully used. The product should also be able to pick up all the trash which comes in its way. Leaving pieces of waste doesn't reduce manual labor as the person picking up the waste will still have to go to the areas where the robot wasn't able to pick up.
- *Unwanted features:* I also noticed the most effective waste picking machines are also the simplest. Adding unwanted technology such as a bionic arm to pick up the trash is often more expensive, dangerous and also less effective. The most effective mechanisms often include simple metal belts moving through basic motors or even just a metal net to catch the trash and not contain the sand.
- *Cost:* The device should also not be too expensive, if the device is expensive local NGOS and business aren't able to afford the device and it becomes for commercial use. For the device to be affordable it should range from 2000 to 6000 rupees.
- *Safety:* The device should consider safety as one of its biggest aspects. The device I am making is an automatic device which will have no human controller and have to clean uneven terrain where many tourists come to visit every day. If safety is not taken into proper consideration the device will not be successful, it is not legal to use on the beach. The device may hurt someone, go in the sea water or even stop working if all the components used in the product aren't up to mark or the safety of the product hasn't been tested thoroughly.
- The final product should also be able to clean waste in a sophisticated manner where the tourists aren't disturbed by the loud sound or the size of the product, but the product should also be big enough that the tourists can see the product and not accidentally step over it and break it.
- *Height / Positioning:* This product should also be built at the *ground level* as the problem many NGOS face while picking up the trash is bending down. If the robot is built on the *ground level* not only will it reduce the need for more parts which need to bend down and also make the robot more fragile but the device will also require less space making it less distracting to users visiting the beach. It is also difficult for humans to pick up all the trash in the way so the device should have a mechanism where it is able to pick up all of the trash which comes in its way.
- *Materials:* Some materials which could be used in the product durable include *MDF, rubber tires, nuts and bolts*. MDF is strong, water proof, light, thin and cheap. This allows it to be the perfect material to be the base of the device. A *strainer type* material could also be used to capture the most amount of trash while straining the sand.
- *Physical Design & Electronics*
 - o Motors: Normal *200 to 500 rpm* DC motors can be used to power 4 wheels as the terrain isn't too rough but needs some power to navigate through.

- o A small trash bag could also be used to store the trash on top of the robot instead of always keeping it in front of the robot.
- o There could be a small heavy metal rolling pin behind the robot so without any external power just using the robot's weight it is able to flatten sand.
- o Sensors: To make the device go in a straight line a sensor like the *gyro sensor* could be used. This sensor ensures that the robot always goes in a straight line even if *external force is applied* or if the robot is moved slightly by uneven terrain. This sensor is also only 2.5mm x 2.5mm x 0.5mm with a mass of only 2.8 grams making it the most space efficient and most accurate sensor to be used in the robot. There could also be an *ultrasound sensor* present in the device to detect any obstruction in its way and work its way around it. This will help increase not only tourists around the robot but also help increase the machine's overall life span. Other than these main sensors there shouldn't be too many sensors because the device only has a limited battery and wasting it on sensors which are not necessary will impact the robots efficacy tremendously.
- o To enhance the safety of the machine there should be a few key takes which need to be taken. *No loose wires*: As this robot will operate autonomously in an uneven terrain where many tourists are present loose wires may not only end up getting stuck in sand the unplugging key points but also if a loose wire hits a tourist there is a high possibility the tourist may get electrified causing major safety hazards.
- o Power (battery): The ideal power which will be needed to power 4, 200 rpm motors, 1 gyro sensor, 1 ultrasound sensor, light and arduino for 200 to 500 meters will be a 2500 to 3000 Ah battery. The device will need a constant of 12 volts to work. The device works for 1 hour then this battery will be enough. The robot will need to have a constant speed of 3.3 Km per hour to achieve 200 meters and 8.3 Km to achieve a distance of 500 meters. On rough terrain such as sand the speeds will easily vary from 3 km to 8 km per hour providing the perfect distance of 200 to 500 meters in just one hour.
- o Night illumination: If working at night the device could also have a small light indicating the device's precise location and ensuring no one accidentally stamps on it and breaks the device.
- *Maintenance ease / daily check-up*: In the device there should be a mechanism from which operators can check on a daily basis if all the parts are operating optimally. Part such as the gyro sensor and motors are essential to work properly, if the gyro sensor is broken/fried by harsh conditions present on beaches the product may end up diverting from its track and go into the sea. If this happens not only will the bot be completely ruined but also the floating parts of the electric device may end up hurting or electrifying a tourist.

CRITERION B: DEVELOPING IDEAS

Bi (Design Specifications): Develop design specifications, which clearly state the success criteria for the design of a solution

Aesthetics 	The product I am planning to make is a beach cleaning device which should be able to clean beaches without any disturbance. For this to be successfully the robot should have a color which should be able to stand out so any human in the vicinity on the device easily able to see and located the device, this will ensure no one accidentally steps on the device and breaks it, however the color should be such that the robot from far away is difficult to spot. This allows the device to be seamless while cleaning the beach, not distracting or taking too much attention from the user. A color which would be most appropriate for such a device would be bright yellow, this color will stand out a lot especially in the evening when a person is next to it, however when people are further away the bright yellow of the robot will perfectly camouflage with the shiny yellow sands of the beaches making it almost invisible. The texture of the product should be smooth, this not only allows the bright yellow to shine and gather the attention of people near it ensuring no one addidentity tramples it but it will also detect sand. Yellow color also gives a feeling of construction and picking up after people's mess. This should hopefully make the tourists realise what a mess they have caused. A smooth texture will guarantee sand will be stuck on the body of the robot. This will also ensure any dirt or rainwater slide of the body. This will tremendously increase the lifespan of the device as it would be extremely difficult for any dirt, dust or other particles to reach the internal circuit and destroy the device. For the product to successfully be able to flatten and roll the sand behind it the weight of the robot should already be 5 to 8 kgs. If the device is lighter than this the sand behind it won't get flatten which is behind it and if the product is heavier than 8kgs it will be too difficult to carry around and with the minimal parts which will be used in this design it will be very difficult to cross the weight limit of 8 kgs without having to add extra weights making the product more bulky and unnecessarily big. To further inform the public and ensure trash is not thrown so products like this don't have to be made there could be small banners which have the recycling, reusing and reducing signs, there could also be no littering signs so during the cleansing of beaches the product also educates the public.
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Customer 	The customers of my product are NGOS and local businesses. NGOS only in Mumbai have 215 volunteers daily working to pick up trash and many of the local businesses are harmed a lot by too much trash as they harm tourism in the beaches. According to local vendors due to excessive trash there is a 60% downfall in their business and their business is struggling a lot now. Many small NGOS who are in their starting phases have a difficult time making a proper change due to the excessive amount of trash present on beaches. The work the volunteers have to do is very back-breaking and the conditions present on the beach aren't favorable to work in. Many volunteers are badly tanned, face major backache which can lead to permanent problems and they do this without any pay. The tools provided by small NGOS are also very basic and can't clean much trash leading to all of the volunteers' hard work not being used to its full potential. The minimum age to be able to operate and handle such a device must be at least 13 years, it is crucial that all safety features are regularly looked into, trash is constantly removed with new empty trash bags being placed and many more crucial features are taken care of. And the maximum age should be 60 years as this product is on ground level and accessing it may be difficult for the elderly, in addition if the product is accidentally switched on and the product needs to be caught a older person may not be able to keep up with the speed of the machine. Many beach and sea animals are also harmed a lot due to plastic waste. Waste that is on the beach such as plastic bags, bottles, etc end up destroying the natural habitat of animals such as crabs, snails, etc. And the rest of the trash which goes in the ocean can harm marine life a lot. Many fish end up eating the plastic thinking of it as food and eventually choke upon it and die.
Cost 	The cost of the product should be such that local businesses and small NGOS in their starting phases are easily able to afford the device, however the price should be enough to give me as a designer enough budget to use all the parts I want and for the parts to be of high quality. The price which would be most suited for such a device will be from 2000 to 5000 rupees. Both the gyro and ultrasound sensor combined will be around 200 rupees, the arduino will be 500 rupees, the chaises along with the motors, wheels and wires will be around 900 rupees, the motor driver will be around 200 rupees and the physical exterior of the robot should be 500 to 1500 rupees. These components give me as a designer enough room to work on but also allow the customer to easily be able to buy the product. This product will be more expensive from the common hand held tools my customers currently use, however this will be much cheaper when compared to robotic tools which can clean trash in more quantity and easily which is what my product's goal is.
Environment 	The aim of the product is to be able to clean to environment by picking up trash from the beach and in the process help local business and NGOS, however according to me as a designer and my target audience the actual materials in the product don't necessary need to be sustainable until the product is able to do its job. Along with my clients even I believe investing in the long term is much better than in the short term, if the product made is not fully sustainable but is able to clean much more trash than a product which is sustainable it will not only be better for the earth but also my target audience. If the product is able to clean an excessive amount of trash it will make the earth a better and cleaner place and also make up for the little harm the making of the product did. In addition the product being able to pick up more trash will help NGOS and local businesses in many ways. However the making of the product shouldn't set off tremendous carbon footprints which it is never able to make up for.
Safety 	Safety in such a device is a major concern and needs to be handled with full attention and care. If safety is compromised in an automated device which works in the open beside tourists in a public place the device will not only be called illegal to use but lawsuits can also be filed against the device. The robot should have basic safety measures which include, <i>No loose wires</i>: It is essential for any electronic device to ensure its wires are secured and don't come out. If the wires start to come out of the product then they could electrify users/tourists at the beach and the loose wires may also get stuck by some dirt present on the beach or wires may get entangled with the wheels of the robot. This will disrupt the whole circuit and the device will stop working. <i>Regular safety check</i>: There should be some way in which the operator of the product can easily see if all sensors, motors and mechanisms are working to their full potential. If the sensors stop working the robot may run into tourists or even divert from its track and end up going into the sea. If the motors stop working the device will completely stop running and if the arduino stops working all sensors and components will not run shutting the device down forever. <i>Physical body check</i>: The operator should also have an easy method to see if the physical body of the product is in proper condition. The physical body not being in proper condition may lead to the sensors and components being damaged easily.
Size 	The product should be of such a size that it is able to safely hold and operate its components and also hold a sufficient amount of trash. Compared to other high end electronic products this will be much smaller in size. To ensure the product is able to store all its components the chassis should be 30 to 35 cm in length and 7 to 10 centimeters in breath, the part which will be responsible for picking up the trash should be 25 liters and for

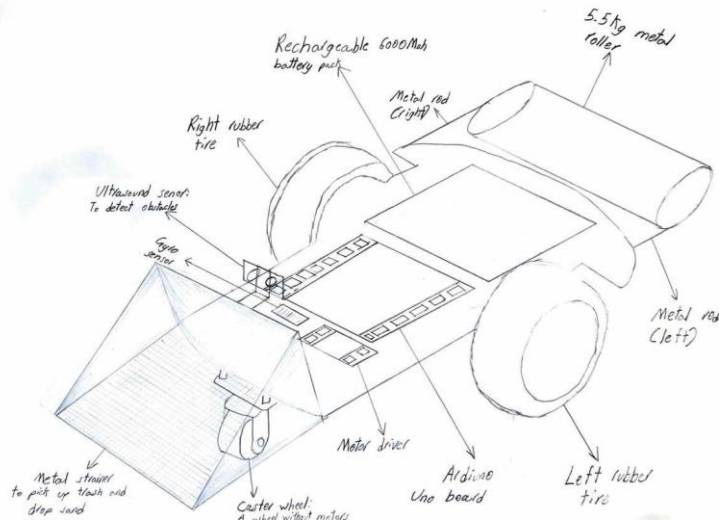
	that successfully happen the part should be length should be 7 to 10 centimeters and 7 to 10 centimeters in length as well. The part which is responsible for flattening the sand should be around 7 to 10 centimeters in length and 3 to 5 centimeters in width. The diameters of the wheels will be 22 to 26 centimeters, this size of wheels will allow the device to navigate its way through rough terrain, however won't make the robot too big in comparison to the chassis. The gyro sensor is 2.5mm x 2.5mm x 0.5mm, ultrasound sensor will be 22x46x16mm, the arduino uno will be 5.3 x 4.3 x 0.8 cm, the size of one motor is 040 × 025 × 055 mm and the size of the motor driver will be 2.5 to 7.5 cm. All these components will be easily fitted inside the chassis of the device and also be secured.
Function 	The main aim of the product is to autonomously be able to clean beaches. The product will work through various sensors and components interacting with each other to make the whole experience of beach cleaning seamless not only for the operators of the product who usually have to manually clean the beaches but also for the tourists visiting the beach. Often all trash can't be picked up by volunteers leading to tourists not wanting to visit the beach. The product should be able to cover 200 to 500 liters with a trash carrying capacity of at least 25 liters. This will give the product a reasonable goal for its small size but also ensure the product is able to make a difference on the beach with each trip it takes. The design and components in the device should also be able to pick up all the trash it encounters. This makes sure manual volunteers don't even have to go in the vicinity of the part where the device has already been. The device will also be able to maintain a straight line and avoid humans due to the advanced sensors present in the device. This permits multiple devices to work at one go, each assigned an area which it is able to clean. The speed of the robot can go up to 8 kmph allowing the robot to be quickly able to complete its job. This is much faster than a human as the average walking speed of a human is 5.1 kmph with the additional time of bending down each time they want to pick something up and also carrying a large and heavy trash bag slowing them down. While cleaning beaches this device will also be able to flatten them providing two fold purpose, most human tools aren't able to do this. Flattening beaches attract more tourists, allow for beach sports to be promoted and also increase the stability of the ground below the beach. While cleaning beaches this product can also spread educational and general awareness about littering the beaches. There could be posters, and banners on the robot for the general public to look at, these posters can educate the public about keeping the beaches clean. There could also be a small trash can on top of the robot, this will allow the device not only to be a beach cleaning device but also provide tourists a fun and easy way to throw their trash. The robot will act like a portable trash can for tourists and especially children will be more eager to throw and aim trash in a moving trash can.
Material 	The product needs to be made of materials which can handle and protect parts inside the device from harsh conditions such as rain, intense heat, dust, sand and even minor storms. The material appropriate for the chassis which will be the main body will be MDF. MDF is light, durable, is able to handle rain, sun and is also dust and sand proof, if MDF is being used extra components which add weight could also be added on top of the robot and it will be able to handle it. The material used in the wheels will be rubber, the main reason for this is rubber wheels are cheap, durable and high in functionality. Rubber wheels will easily be able to handle the rough terrain which is put in front of it. Rubber wheels are also extremely cheap with them only being 100 to 200 rupees for a set of 4 and also water and dirt proof. Metal nuts and bolts will also be used to secure all the components into their places. These strongly secure the components for lifetime, take less space and are also extremely cheap.

Bii (Design Ideas): Develop a range of feasible design ideas, which can be correctly interpreted by others

Drawings - Varish Agarwal Design I ("VA I")

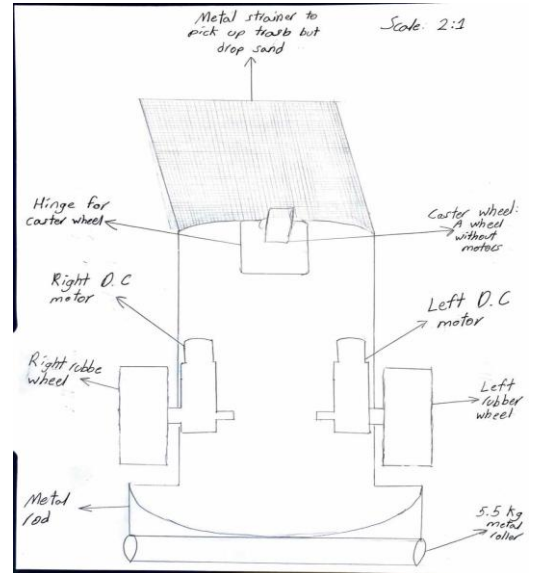
Front Design

Scale: 2:1



Back Design

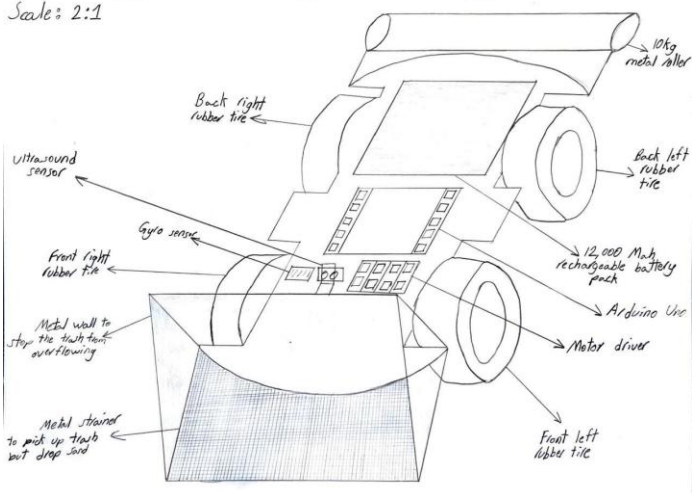
Scale: 2:1



Drawings - Varish Agarwal Design II ("VA II")

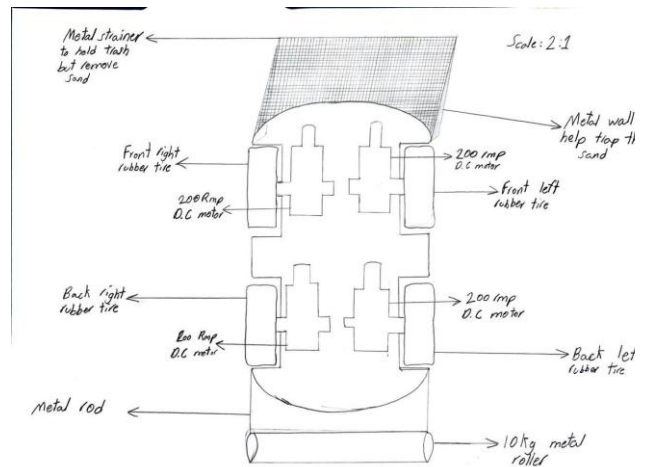
Front Design

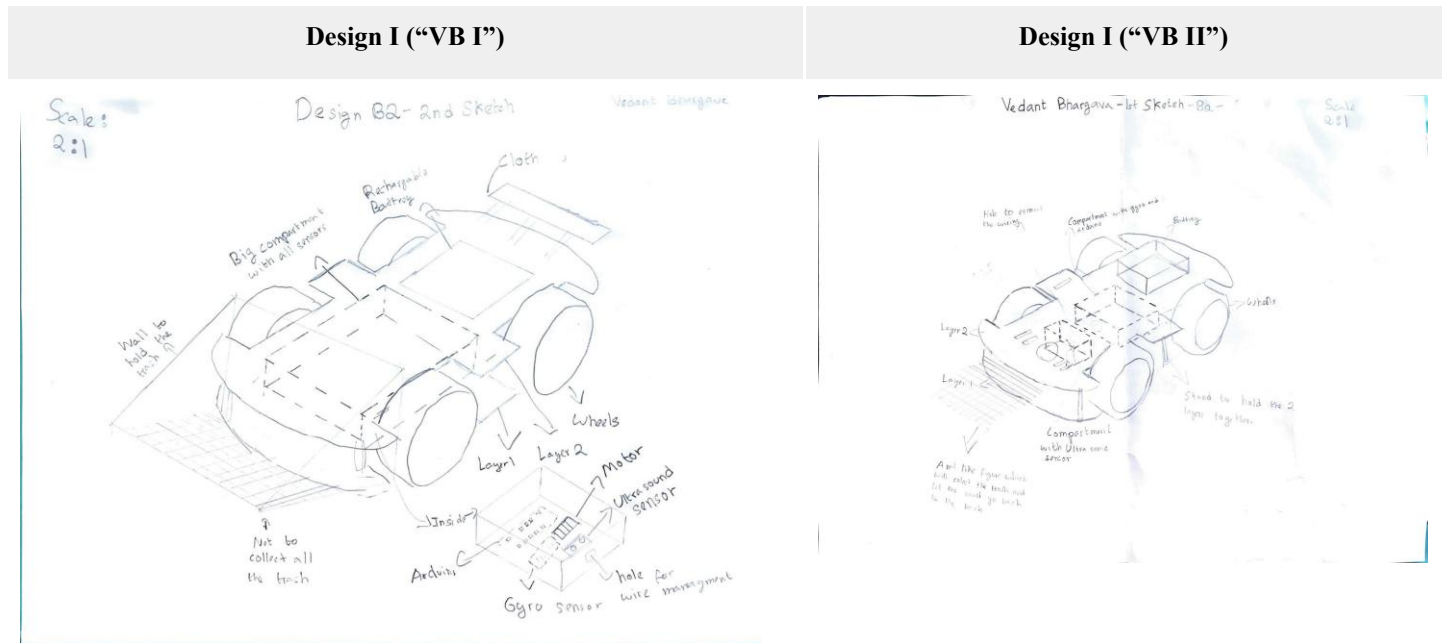
Scale: 2:1



Back Design

Scale: 2:1





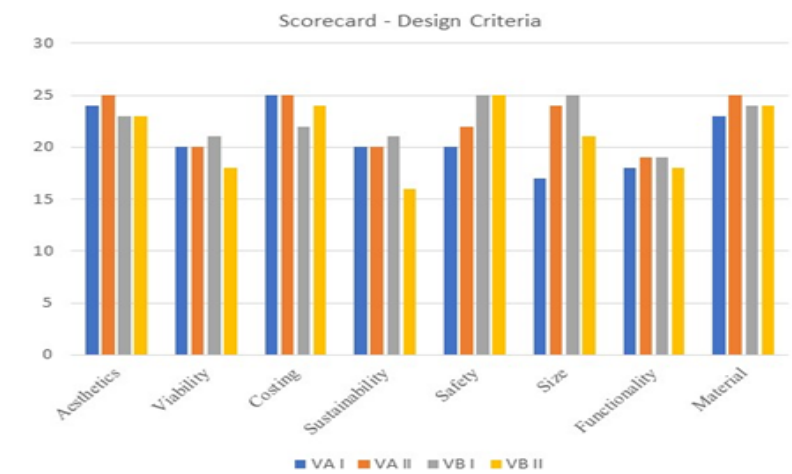
Biii (Chosen Ideas): Present the Chosen Design and Justify its Selection

Balanced Scorecard

- I conducted a survey, whereby participants were asked to rate eight (8) design criteria i.e. Aesthetics, Viability, Costing, Sustainability, Safety, Size, Functionality and Material on scale of 1-5, with 5 being highest.
- The feedback was tabulated to create a scoreboard.
- For example if 4 surveyor rated a particular design "5" in aesthetics, whereas 1 surveyor rated the design a "4" in aesthetics, the design score would be – Aesthetics is "24" [(4X5)+(1X4)]
- Overall scores computed by summation of criteria-wise score. Alternatively, I could have also computed weighted overall score (higher weights being provided to more important criteria)

Key observation from survey

- All the 4 designs were well appreciated by participants
- All the 4 designs scored highly on Aesthetics, Costing, Safety, and Material
- VA I scored low on Viability, Size, and Functionality
- VA II and VB I scored similar on most parameters
- VB II scored low on Viability, Sustainability, and Functionality



Design wise feedback: The feedback has helped me get a better understanding of what can be used for beach trash clean-up and which designs people are more inclined toward while helping me choose the appropriate final design.

VA I	Surveyor I	Surveyor II	Surveyor III	Surveyor IV	Surveyor V
Aesthetics	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★☆☆
Viability	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆
Costing	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Sustainability	★★★★★	★★★★★	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆
Safety	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆
Size	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆
Functionality	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆	★★★★★☆☆
Material	★★★★★	★★★★★	★★★★★	★★★★★☆☆	★★★★★☆☆

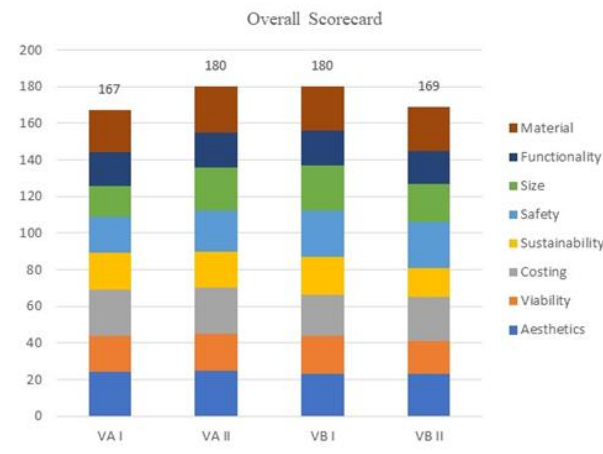
VA II	Surveyor I	Surveyor II	Surveyor III	Surveyor IV	Surveyor V
Aesthetics	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Viability	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Costing	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Sustainability	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Safety	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★☆
Size	★★★★☆	★★★★★	★★★★★	★★★★★	★★★★★
Functionality	★★★★☆	★★★★☆	★★★★☆	★★★☆☆	★★★★☆
Material	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★

VB I	Surveyor I	Surveyor II	Surveyor III	Surveyor IV	Surveyor V
Aesthetics	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★☆
Viability	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Costing	★★★★★	★★★★★	★★★★☆	★★★★☆	★★★★☆
Sustainability	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Safety	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Size	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Functionality	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Material	★★★★★	★★★★★	★★★★★	★★★★★	★★★★☆

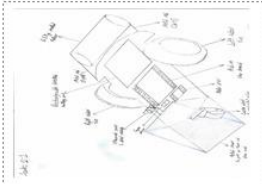
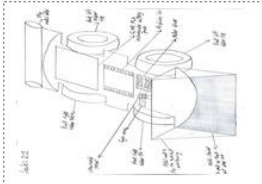
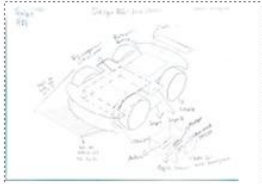
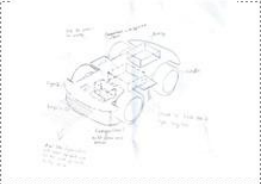
VB II	Surveyor I	Surveyor II	Surveyor III	Surveyor IV	Surveyor V
Aesthetics	★★★★★	★★★★★	★★★★★	★★★★☆	★★★★☆
Viability	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Costing	★★★★★	★★★★★	★★★★★	★★★★★	★★★★☆
Sustainability	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Safety	★★★★★	★★★★★	★★★★★	★★★★★	★★★★★
Size	★★★★★	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Functionality	★★★★☆	★★★★☆	★★★★☆	★★★★☆	★★★★☆
Material	★★★★★	★★★★★	★★★★★	★★★★★	★★★★☆

Overall Scoreboard

- VA II and VB I scores tied at 180 points, whereas VA I received lowest score of 167 points
- Improving on Sustainability and Functionality will help further improve overall score
- Overall high scores make it challenging to make significant improvement in the product



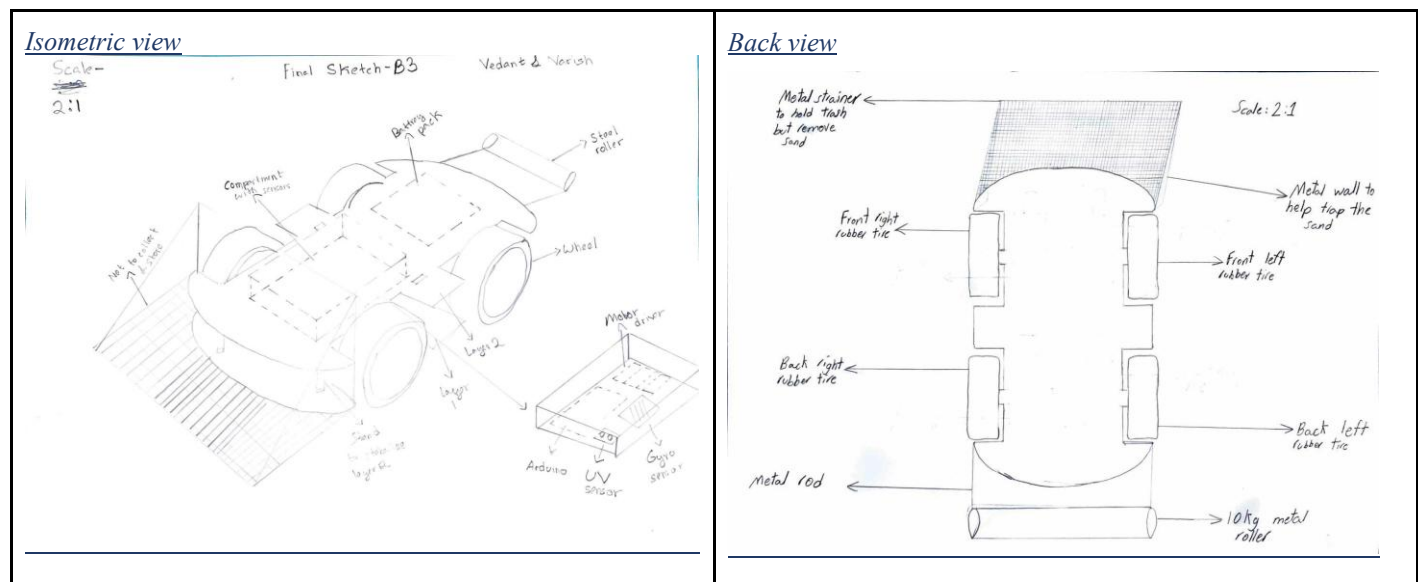
Evaluation of Designs: After creating a range of several design ideas and evaluating them from various sources .Here is a table incorporating the evaluation process of all final design ideas, clearly depicting and justifying the reason for the chosen design

	Varish I ("VA I")	Varish II ("VA II")	Vedant I ("VB I")	Vedant II ("VB II")
Wheels	Three (3)	Four (4)	Four (4)	Four (4)
Chassis (Layer)	Single	Single	Double	Double
Motors	Two (2)	Four (4)	Four (4)	Four (4)
Batteries (MaH)	6	12	12	12
Roller	5.5 Kg	10 Kg	NA	NA
Trash Bucket	Medium	Large	Large	Small
Length	Smaller	Medium	Medium	Medium
StrawmanDesign				

Summary of feedback that was incorporated

- I will primarily use VA II design as the base design, while incorporating some of the best elements of VB I
- Double chassis would be added in VA II design instead of VB I
- The rest including the roller and trash picking up bucket will remain the same

Final sketch

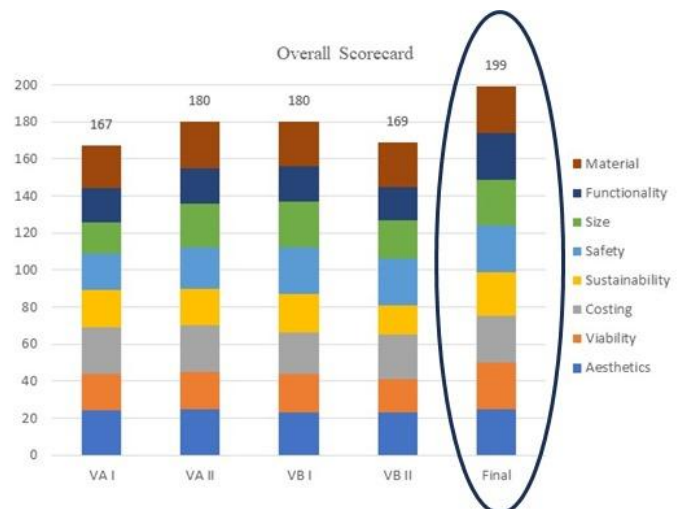


Justification of Chosen Design

After a lot of feedback and self reflection I came to the conclusion to get the best design which will help improve the product overall will be combining both our designs to make a final sketch. We both had some good ideas and unique perspectives and combining the pros of both in one sketch will make for an almost perfect product. Here are some pros of the final design which were missing from our individual designs

Summary	Pros	Cons
Varish II (VA II)	✓ Had a big trash storage capacity ✓ Is 4x4 device allowing it to navigate in complex terrain ✓ Could easily avoid humans ✓ Had a good and easy system to flatten the beach ✓ Had a good battery life	✗ Only had one layer making it vulnerable to harsh weather conditions ✗ Wires were exposed ✗ All the sensor were exposed
Vendant I (VA I)	✓ Has 2 layers making is resistant to harsh weather conditions ✓ Has a big trash storage capacity ✓ Is 4x4 device allowing it to navigate in complex terrain	✗ Doesn't have a good back roller hence can't flatten the sand ✗ Has a low battery capacity ✗ Wheels are meant for sand
Final Prototype	✓ Had a big trash storage capacity ✓ Is 4x4 device allowing it to navigate in complex terrain ✓ Could easily avoid humans ✓ Had a good and easy system to flatten the beach ✓ Had a good battery life ✓ Has 2 layers making is resistant to harsh weather conditions	

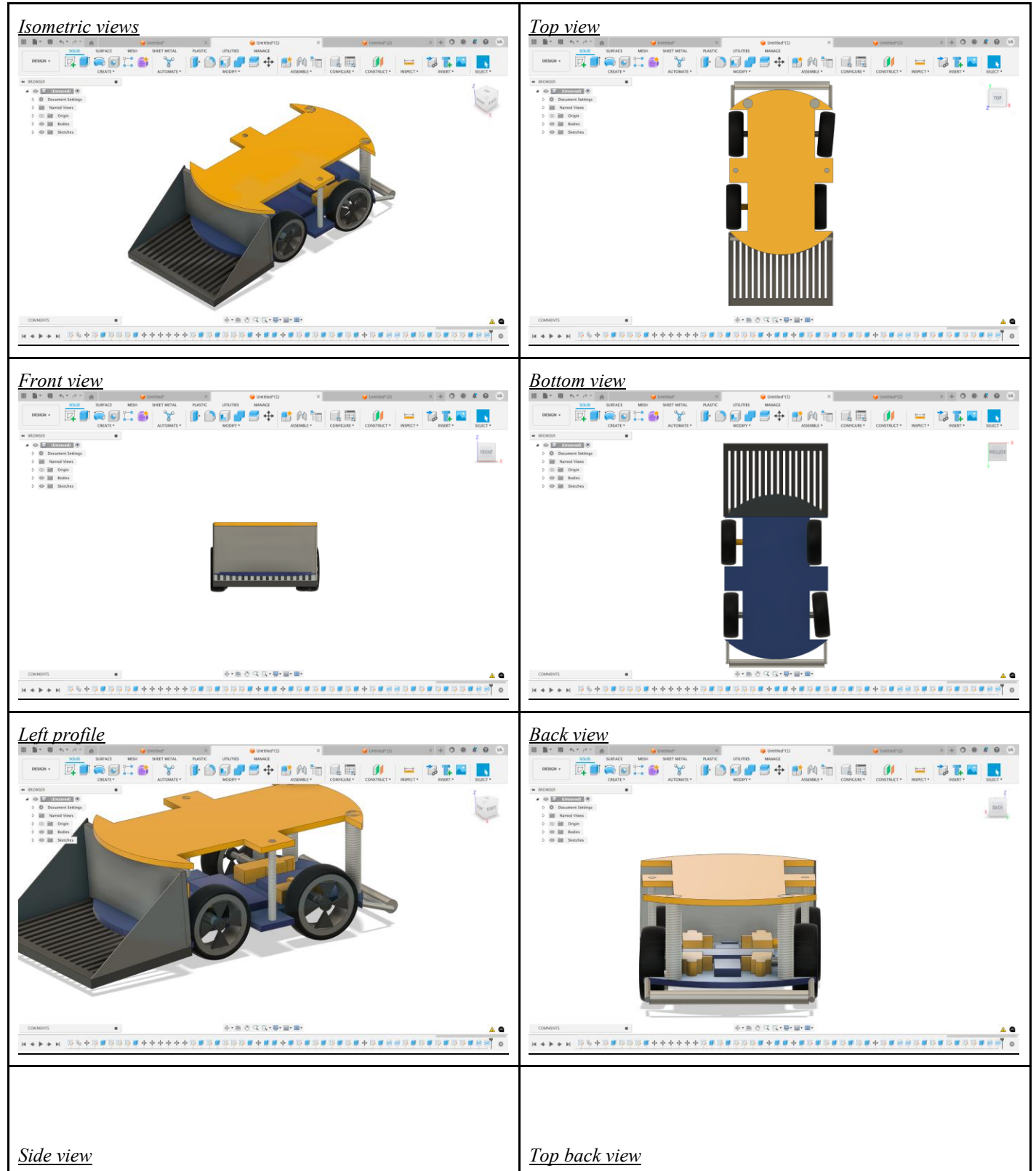
Overall, according to the clients and myself as a designer, combining both ideas to make a final sketch allowed both your unique perspective to show and for the final sketch to be nearly flawless. The overall score in VA II and VB II was also 180 points while the final product was able to reach the score of 199 out of 200.

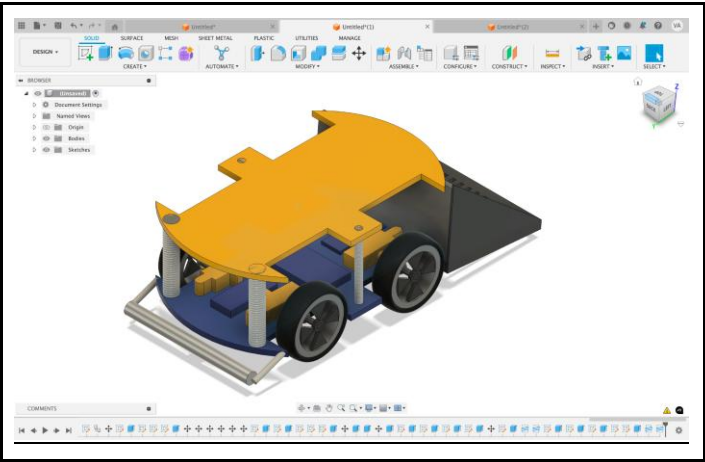
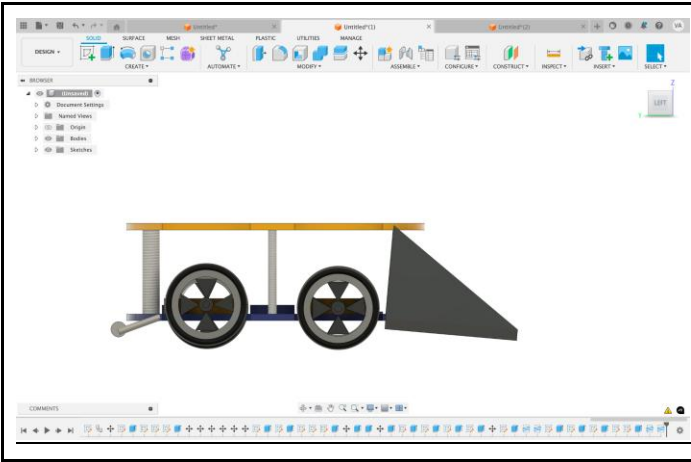


Biv (Detailed Plans): Develop a detailed Design Brief, which summarises the analysis of relevant research

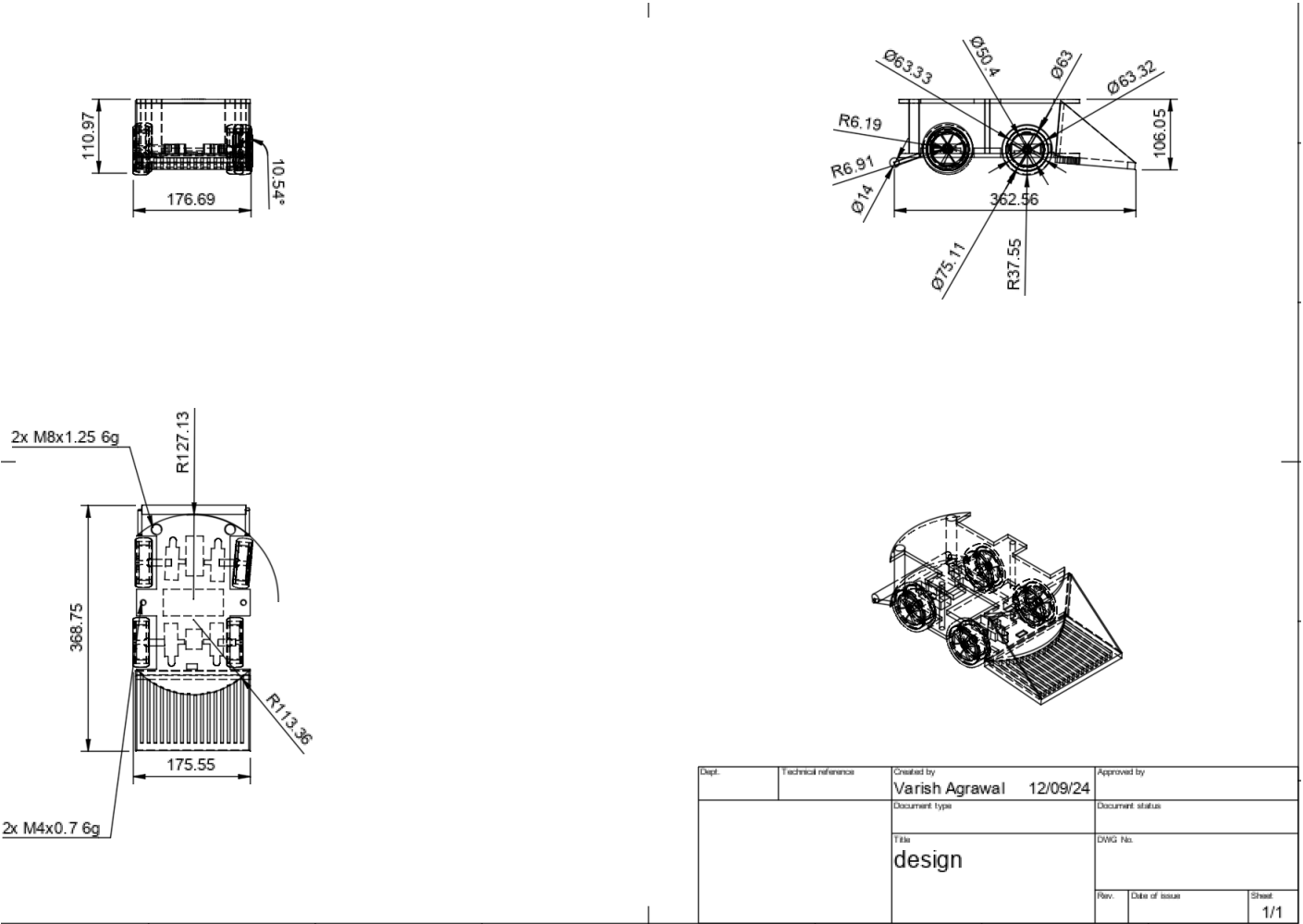
Planning the drawings made it possible for me to have a very clear idea of what the final product will need to look like, including how the trash bucket will be designed, weight of roller, and how it should look from Aesthetics perspective.

CAD model:





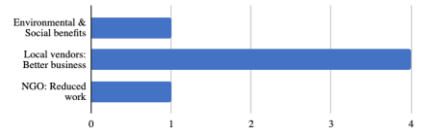
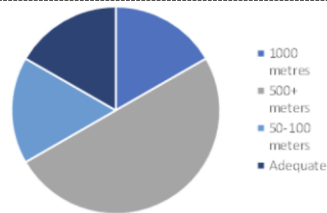
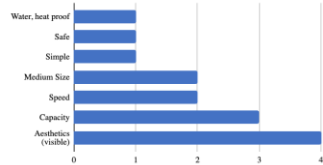
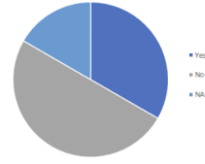
Final isometric view with dimensions (all measurements in mm)

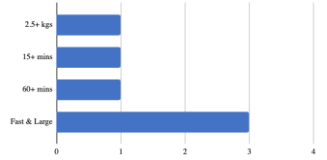
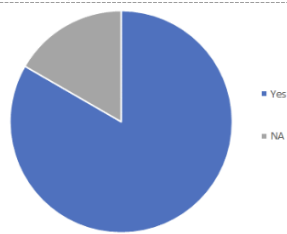


Component	Dimension	Quantity	Material
Chassis	36.6cm x 15cm x 3cm	2	MDF
Wheel	Circumfrance: 6.6mm	4	Rubber
Arduino Uno		1	Metal
Gyro sensor (angular velocity sensors)		1	Metal
Ultrasound sensor (HC-SR04)		1	Metal
Roller	17cm x 3cm	1	Stainless steel
Metal grid	6.3cm x 17cm	1	Metal
Battery		1	Lithium
Direct current motor		4	Metal + plastic
L293D, dual H-bridge motor driver		1	Metal
Poll	3cm x 1cm	2	Metal
Side walls	12cm x 9cm	2	Metal
Back wall	8 cm x 16.7cm	1	Metal

APPENDIX A: PRIMARY RESEARCH

1.1 Primary Research

Question	Relevance	Data and Results
To what extent will cleaner beaches help your business/NGO and why is that?	This is arguably one of the most important questions to understand the purpose of the product. The answer to these questions will help me understand on a local and personal scale if the problem really exists and the depth of the problem.	 Majority of the participants (more than 66%) felt that there would be a significant positive impact on local vendors. Other stated benefits included reduced efforts by NGO to clean beaches and socio environmental benefits of cleaner beaches along with efficient disposal of beach waste.
How much area would you want one device to cover in the span of one battery life?	As a designer it is really important for me to know the total output the clients are expecting out of the product that can work according to those specifications. If my clients are expecting that the range be really long then weight, speed, battery life, etc will need to be adjusted accordingly.	 Only one participant felt 50-100 meters range would be sufficient, whereas clear majority is for at least 500 meters of coverage. One participant also felt that the product should have higher range of 1km
Would there be anything specific you would want in the product (looks, speed, capacity, size, weight, etc)?	Knowing what the users want from the product is a crucial part for user satisfaction and product optimization. The clients have been in the beaches for way longer than I have as a designer, due to this they consume more knowledge about beach clean ups and their advice could help boost many factors such as function, aesthetics, etc for the product.	 Most respondents wanted product to be easily visible to avoid accidents. Range / Capacity of the product, speed and product size were stated as additional critical success factors for the product.
To what extent does the sustainability of the actual product matter to you?	It is important for me to know how much certain aspects of the product matter to my client. The product I am making wants to achieve the UN goal of Climate actions, which is directly linked to sustainability, hence my clients may think having a sustainable product is very important to fully achieve this goal. However, in my opinion, to optimize the usage of the product, non sustainable materials are necessary.	 Given the product application 50% of the participant felt that sustainability was not an essential driver for the product. It would make sense to keep sustainability in perspective without compromising on materials used and design adopted

Question	Relevance	Data and Results
What is the ideal capacity the device should have to pick up trash and how fast should the device be able to pick up trash?	It is crucial for me to know the expectancy of trash my clients expect my device to be able to pick up. Understanding the client's expectations is a crucial step to make the final product successful. The product size, efficiency and power will be based on this answer.	 Feedback suggests that the product needs to balance between waste handling capacity and power / battery usage. Higher speed and waste handling capacity will require higher power and therefore reduce full charge cycle of the product
How can the automated device avoid humans' effort and clean the beach in a sophisticated manner?	Avoiding obstacles such as humans is not only crucial for human safety but also for optimal usage safety of the device itself. If the device hits a human not only will the human get severely injured, but the device may also break if it repeatedly comes near the human. Someone may step or flip the automated device putting it out of use until a human flips it back or even completely breaks the device.	 The survey feedback says that automated device would be disciplined and provide a long term solution. Some of the other benefits included high quality cleaning, cost effective and consistent performance. Some of the feedback providers also felt that benefits would include ability to work in non-peak hours and without disturbing (non-intrusive)
What is the most challenging part while picking up the trash and how will an autonomous device be able to improve this?	Knowing the challenges which humans face while picking up waste can help me as a designer to take notes and make a device which future improves on that. For example if humans have difficulty bending down each time they want to pick up the waste the device could be made at a ground level so it doesn't have to bend.	 Complete consensus on these questions with no negative response. This reinstates original hypothesis that an autonomous beach trash cleaning machine will be of great value to society

1.2 Secondary Research

Question	Relevance	Source
What physical components could be used while creating such a device for optimal usage?	When it is time for the physical creation of the product it will be extremely important to know which parts are to be used where. Regardless of the code or the sensors used, if the physical parts are not up to the mark or don't fit with the components then the product will not be able to function.	 https://sphero.com/blogs/news/how-to-build-a-robot

Question	Relevance	Source
Which sensors could be used while creating a product to make it go in a straight line?	Sensors are a crucial part of making any automated device. Having the correct sensors can transform the whole product drastically. For example, to make my product go in a straight line, choosing the correct sensor is very crucial. If the correct sensor is chosen then the product will be able to easily cover the area it is supposed to and return to its original position, however if the wrong sensor is used then the product may end up drifting and going inside the ocean.	https://gamzenindia.com/tips-for-maintaining-your-beach-cleaning-machine/#:~:text=B.&text=Some%20beach%20cleaning%20machines%20use,to%20ensure%20it%20operates%20optimally.  https://stemrobotics.cs.pdx.edu/node/5199.html#:~:text=A%20Gyro%20(gyroscope)%20sensor%20can,to%20control%20direction%20of%20travel. https://www.quora.com/How-can-a-robot-move-in-straight-line-other-than-line-follower#:~:text=A%20gyroscopic%20sensor%20o%20sense,to%20get%20a%20straight%20line.
Which safety features should be in a beach cleaning automated device?	Safety features in any product is always a top priority and needs to be handled with the utmost care. Without proper safety features the product could be dangerous to operate and made illegal to use. A lack of safety precautions could also harm or seriously injure the pedestrians on the beach.	 https://kccemsr.edu.in/public/files/technovision/1/SMART%20BEACH%20CLEANER%20VEHICLE.pdf
What is the ideal power that will be needed to power an automated device?	After knowing the distance the device will have to go it is also important to get to know the ideal power which will be needed. According to the power which can be provided the usage of certain parts and components will also be decided. For example if a sensor takes more power that can be provided to it then the sensor will be of no use and different components will have to be used.	 https://www.componentsbureau.com/latest-news/industrial/powering-your-future-choosing-the-right-power-supply-for-industrial-automation https://www.quora.com/What-is-the-power-consumption-of-the-control-box-of-an-IoT-smart-home-automation

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