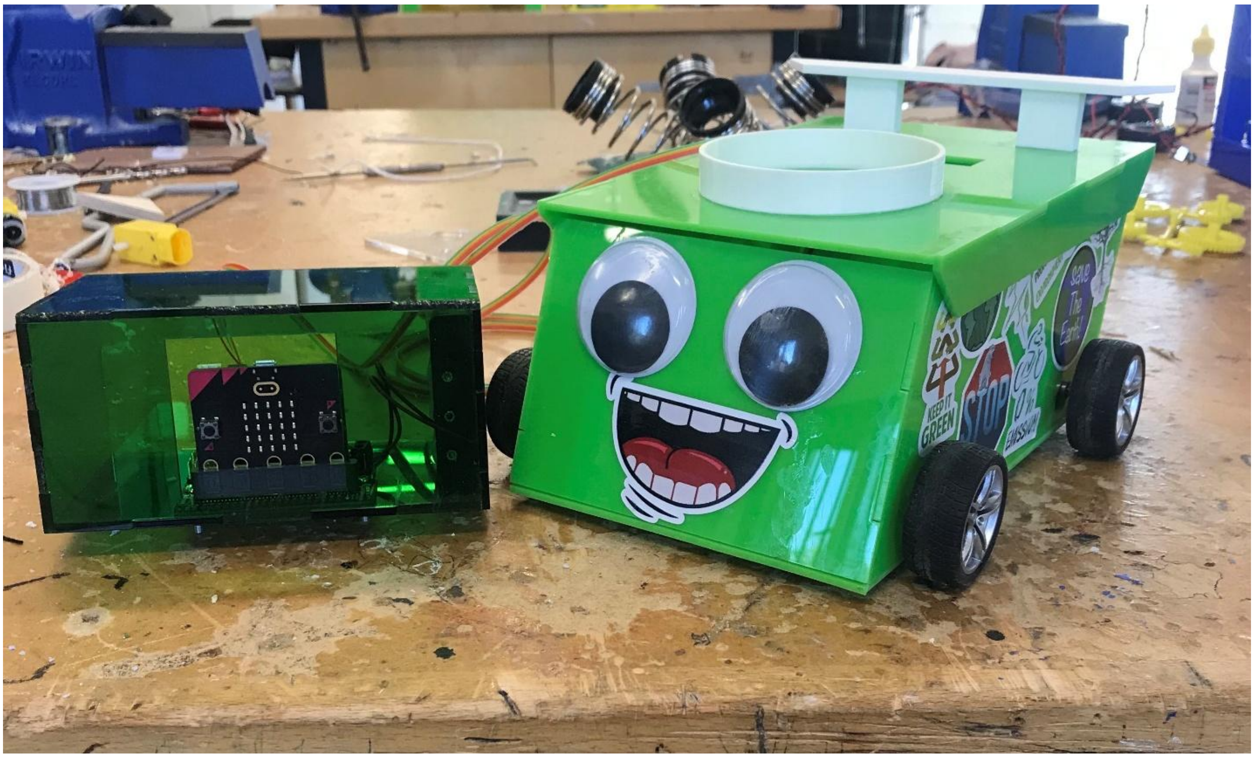
Leaving certificate

Technology

2024/2025



Higher Level Thematic Brief

Exam Number: 206444

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Instructions to examiner

Before attempting to use my project, please ensure:

1. 4 new AA batteries are in the battery clip.
2. There is enough cable slack for you to hold the controller while the car is on the floor.
3. The Kitroniks board is turned on. This is indicated by a green light flashing on the board.
4. There is enough space to operate the vehicle, so that it will not crash into any surrounding objects.

To operate the car:

1. Remove the top panel of the controller.
2. Ensure there are 4 batteries in the battery clip. If not, insert 4 into the clip.
3. Turn on the Kitroniks board, this is done by flipping the off/on switch on the board. A green light will flash from the board.
4. Put the top panel back onto the controller.
5. Use the front of the controller to control the vehicle by pressing buttons and A and B on the Microbit.
6. Button A will make the car go forward (an up arrow will show).
7. Button B will make it reverse (a down arrow will show).
8. Pressing both buttons simultaneously will make the car turn (an ‘S’ for Spin will show. The light will alternate between forward and reverse ‘S’).
9. To stop the motors, press the Microbit logo at the top of the Microbit.
10. After use, turn off the Kitroniks board.

Analysis of thematic brief

Brief:

Thematic Brief Goal 12 of the United Nations Sustainable Development Goals focuses on ensuring sustainable consumption and production patterns, which are vital for preserving the livelihoods of both current and future generations. With the planet facing resource depletion and an increasing global population projected to reach 9.8 billion by 2050, it is imperative to address the challenges of sustainable consumption and production (adapted from https://sdgs.un.org/goals/goal12). As individuals, we can practice responsible consumption in many areas of our lives, such as; food, water, energy, transportation, clothing, textiles, and waste management. By being mindful of our consumption habits and making conscious choices to reduce our environmental footprint, we can play a significant role in promoting sustainability and protecting the planet for future generations. In a context of your choice, and with a focus on modern materials and processes, design and manufacture a working model of a device, system, product, or interactive display that promotes or contributes to sustainable consumption in our lives. Your solution should include an electro-mechanical element and should also be well presented. Note: The maximum dimension of the artefact you present for assessment should not exceed 500 mm. If multimedia presentations are used to enhance your display, a hardcopy printout and a digital file (USB flash drive) must be included in your portfolio.

Key factors:

- Sustainable Development Goals
- Resource Depletion
- Waste Management

- Modern Materials
- Processes
- Sustainable Consumption
- Electro-Mechanical Element

In my analysis of the thematic brief, I would like to include the following titles to discuss and research further into. By analysing the titles, I believe it would help me achieve a better understanding of the brief and possible solutions.

Sustainable Development Goals: These are goals set by the United Nations in order to end problems in the world like poverty and world hunger, for example, so that people all around the world can live in peace and prosperity. This was set in 2015 and aims to have all 17 goals completed by 2030. An example of one of the goals is Clean Water and Sanitation (SDG 6).

Resource Depletion: This is when both renewable and finite resources become scarce due to them being consumed too fast. This leaves the resources to run out before they can recover.

Waste Management: Waste Management involves disposing of waste materials but through the processes of sorting and recycling. This helps to reduce all effects of waste on human health and the environment.

Modern Materials: These are materials that are designed to meet certain technological, environmental and aesthetic needs. This can include smart materials, composites, biodegradable materials, and 3D printed materials.

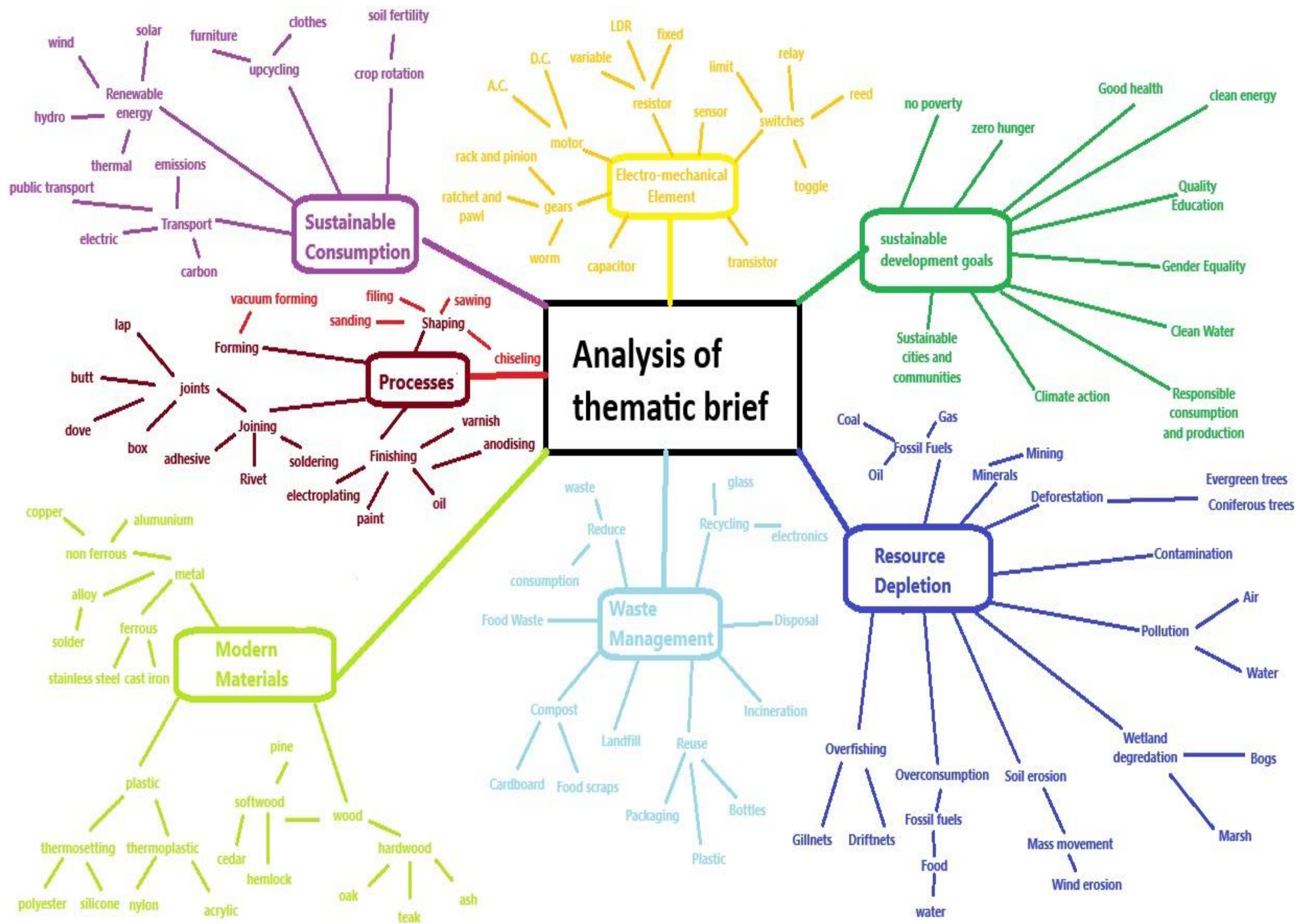
Processes: This is a series of operations that systematically takes inputs like materials and turn them into our desired outputs. This could involve both hardware and software elements.

Sustainable Consumption: This involves the use of goods and services to meet our needs while minimizing environmental impact and preserving resources. It encourages promoting ethical practices to consumers, businesses, the government etc.

Electro-mechanical element: An element that specifically combines electrical and mechanical processes to perform a function that we need. An example is motors, switches, relays etc.

How can my project relate to the thematic brief and reduce environmental impact?

The remote-control football delivery car I have manufactured directly promotes sustainable consumption by serving as an engaging and visually striking promotional tool. Its colourful and vibrant green body along with many sustainability stickers catch attention and raises public awareness of responsible consumption. The reusable and interactive nature of the vehicle creates an innovative way to convey environmental messages. In large stadiums with many people, the vehicle would be not only be a fun way to grab attention but also make sustainability impactful and accessible to anybody. Additionally, its durable acrylic body reduces waste compared to traditional promotional products. If I were to manufacture a second football delivery car, I could possibly incorporate recycled acrylic or solar panels to power the vehicle and enhance its environmental benefits.



Analysis of thematic brief
Sustainable Consumption
Renewable energy
wind
solar
hydro
thermal
Transport
public transport
electric
carbon
emissions
upcycling
furniture
clothes
crop rotation
soil fertility
Electro-mechanical Element
motor
A.C.
D.C.
resistor
LDR
fixed
variable
sensor
switches
limit
relay
reed
toggle
gears
rack and pinion
ratchet and pawl
worm
capacitor
transistor
sustainable development goals
no poverty
zero hunger
Good health
clean energy
Quality Education
Gender Equality
Clean Water
Responsible consumption and production
Climate action
Sustainable cities and communities
Processes
Forming
vacuum forming
Shaping
filing
sawing
sanding
chiseling
joints
lap
butt
dove
box
Joining
adhesive
Rivet
soldering
Finishing
varnish
anodising
oil
paint
electroplating
Resource Depletion
Fossil Fuels
Coal
Gas
Oil
Minerals
Mining
Deforestation
Evergreen trees
Coniferous trees
Contamination
Pollution
Air
Water
Wetland degredation
Bogs
Marsh
Soil erosion
Mass movement
Wind erosion
Overconsumption
Fossil fuels
Food
water
Overfishing
Gillnets
Driftnets
Waste Management
Reduce
waste
consumption
Recycling
glass
electronics
Food Waste
Disposal
Compost
Cardboard
Food scraps
Landfill
Reuse
Packaging
Plastic
Bottles
Incineration
Modern Materials
metal
non ferrous
copper
alumunium
alloy
solder
ferrous
stainless steel
cast iron
plastic
thermosetting
polyester
silicone
thermoplastic
nylon
acrylic
wood
softwood
pine
cedar
hemlock
hardwood
oak
teak
ash

Overall Management of Project

I have 1 double class and 3 single classes of Technology per week. The project work will be designed and manufactured during the double classes and 2 single classes over the course of a 26-week period. In order to not waste time, I have set out a plan on how I will manage the project below.

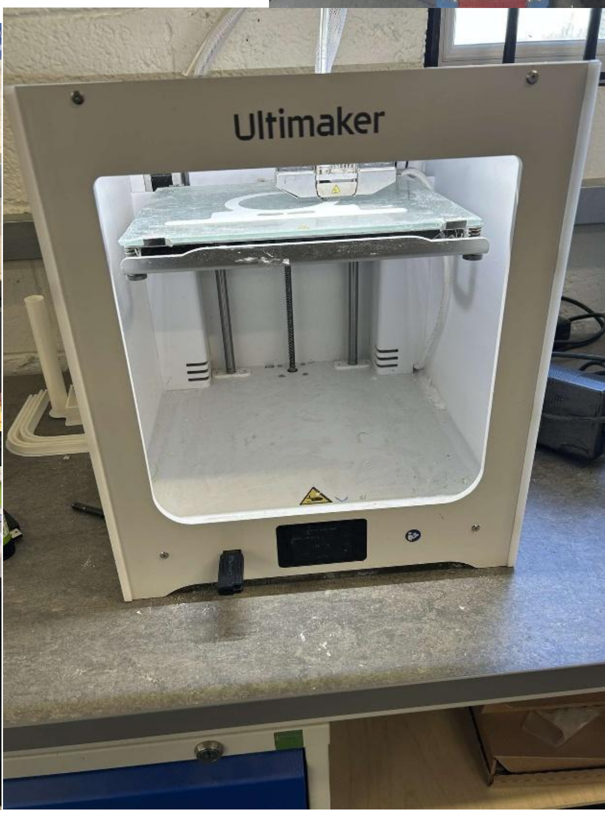
Time (weeks)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Analysis of thematic brief																										
Overall management of project																										
Research, investigations and specifications																										
Design ideas and selection of solution																										
Sketches and drawings for manufacture																										
Environmental impact																										
Production Planning																										
Product realisation																										
Evaluation and critical reflection																										

Task Dependencies:

1. Analysis of thematic (task 1) brief must be completed before research, investigations and specifications (task 3).
2. Design ideas and selection of optimum solution (task4) along with sketches and drawings for manufacture (task 5) must be completed before production planning (task 7).
3. Production planning (task 7) must be completed before product realisation (task 8).
4. Product realisation (task 8) must be completed before evaluation and critical reflection (task 9).

Resources: I have access to a fully equipped Leaving Cert Technology room. Machine tools available to me include pillar drill, bandsaw, strip heater, scroll saw, vacuum former and laser cutter. I also have access to a 3D printer also which can help produce anything I design on CAD. There is a wide availability of metals, plastics, and wood also. I must pay for any materials I want to use and want to keep as low as possible.

I also must consider my own skill level. I must be able to make my final solution in the Technology classroom. If I make the design too difficult it will be hard to complete within the time. The project folder must be completed within the same time so I will need to allocate some of my class time to documenting my work on a PC.



To properly manage this project, I need to assess the risks involved with manufacturing it. Below I have developed a table outlining potential issues and how I will tackle them if they do occur.

Risk Assessment Table:

Risk	Description of risk	Mitigation strategy
Time Constraints	Delays on design and CAD could push back product realisation.	Stick to the Gantt chart schedule and add buffer time if needed.
Component Failure	Electronic components such as motors may not work as expected.	Test the circuits beforehand and keep spare components ready.
Technical Difficulties	Issues with the 3D printer or laser cutter could arise.	Have alternative fabrication methods.
Material Availability	Materials such as acrylic may be unavailable, causing delays in production.	Have backup options for materials and source all needed materials early.
Health and Safety	Injuries involving tools such as saws, drills etc.	Follow safety procedures and wear protective gear.
Measurement Accuracy	Errors in measurement can affect the final outcome of the project.	Double check all measurements before cutting or assembly.
Documentation Timing	Balancing documenting the project with the actual production of it may be challenging.	Set specific times for the portfolio and product realisation. Stick to scheduling on Gantt chart.

Environmental Impact

From the start of this project, I have had to think about the impact that it will have on the environment. As the theme of this project is sustainable consumption, it is important that the project is environmentally friendly and cut down on the use of fossil fuels which emit harmful fumes when burnt to generate electricity.

I chose to make this project from 3mm acrylic and PLA. Even though PLA is biodegradable, acrylic is not as friendly to the environment than wood. I chose acrylic because I have made many projects from acrylic, and it is very easy to achieve a good finish on acrylic.

A big disadvantage is that acrylic is made from crude oil and sometimes coal which are not a renewable energy source. A lot of energy is used to produce acrylic. This involves energy to extract the crude oil and coal from the ground, the energy used to produce the raw material and the energy to transport the material to the stores for sale.

However, on the positive side it would be possible to recycle most of the plastic used into other projects. Recycling the acrylic would help reduce the demand on crude oil to produce new acrylic. Also, acrylic is a thermoplastic which means it can be heated and remoulded into new useful products. PLA on the other hand requires industrial composting conditions. Making sure it is disposed of properly or exploring alternative biodegradable materials would enhance sustainability.

I have also designed the project to use a minimum amount of material to reduce waste. I could have made a massive vehicle, but this would only have used more acrylic and would not make the model work any better than it does.

The advantage of wood is that it is a renewable energy source, but I do not think that this project would look or work as well as it does with wood. If I were to make this project again, I would use renewable materials such as wood. This would include the base, walls, roof etc. This would improve the environmental impact of the project.

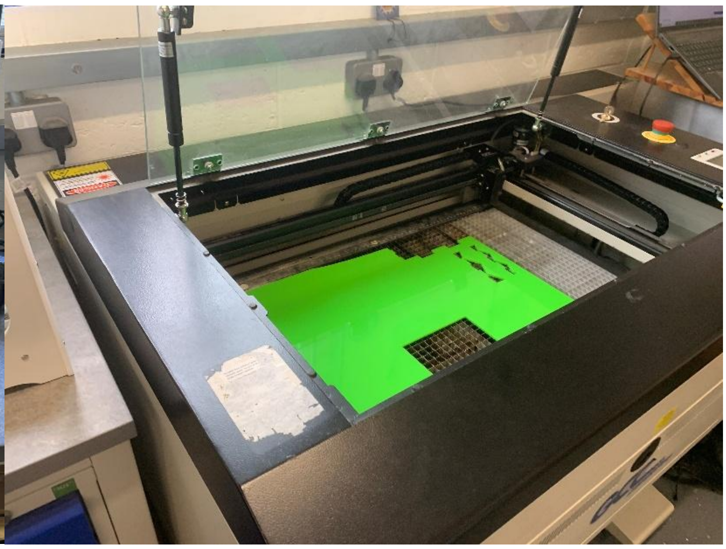
Wood based options, such as birch plywood, medium density fibreboard and bamboo could have been a more renewable material option all while maintaining the same durability offered by acrylic. Plywood is strong and long-lasting, but bamboo is eco-friendly and is fast growing. To achieve a sleek finish, it would have required additional surface treatment like varnish, unlike acrylic.

There were other plastic options that could have been explored which involved biodegradable or recycled plastics. Recycled PET offers similar durability to acrylic but with less of an environmental impact. There is also bio-based polycarbonate which is also strong and is sourced from plants.

Another possible material class could have been natural fibre composites. This includes fibre-based bioplastics or hemp-based composite materials. They offer lightweight durability and are being increasingly used in sustainable product design. They are not as widely available as acrylic but would align more with the project's sustainability goals.

Efforts could be made to upcycle the acrylic when the project is no longer in use. The acrylic could be reshaped and remoulded into new parts for other products. Any scraps from the laser cutter could be melted down and reformed into more components. This overall reduces waste of all the acrylic being used to produce the vehicle.

Electricity used to power the vehicle involves the 4 AA batteries that power the Microbit and Kitroniks board. Along with this, there was an environmental impact from using a 3D printer along with a laser cutter to produce various parts. If I was to redo the project, I would make my parts by hand rather than use energy unnecessarily. It may have been more sustainable to power the vehicle through a rechargeable battery or adding solar panels to the top of the car. The 3D printer settings were optimised to minimise energy consumption and material waste. This included optimising infill percentage and print speed.



In conclusion, there is an environmental impact in making this project. From material selection to energy usage, the impact may be considered not fully sustainable, but a better option than using large amounts of materials like wood which would lend to deforestation. Materials were kept to a minimum and energy was used only where necessary.

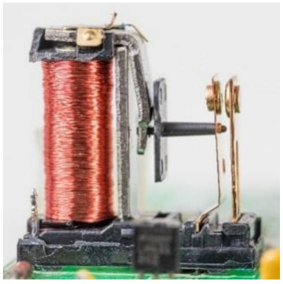
Research, investigation and specifications of brief

Function

Different type of electronics:

Toggle switch: toggle switches are actuated by a lever angled in one of two or more positions. The common light switch used in household wiring is an example. Good for a simple switch, bad because it does not have any other functions.

Relay Switch: Mechanical electrical switch that is electrically activated. They are often used to provide a safe way of switching on and off devices that require high currents.

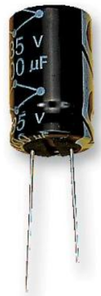


Limit Switches: These are switches that break an electrical connection when an object meets the actuator. It would be good for a project if we needed to make a door or sliding slab but would not be needed for many other scenarios. Not needed for many other scenarios.

Reed Switches: These switches can be activated via magnets or electromagnetic coil. This would be a practical choice for a project that would need a proximity sensor. However, if they are not applied correctly, they can be damaged or permanently broken.

Transistors: These devices are semiconductors. They can be used to amplify the current of a circuit or act as a switch. This would be helpful for a circuit that needs a large amount of current but can get damaged if overheating.

Capacitors: This electronic component stores electrical energy. This would be good for a project that requires energy storage or electronic noise filtering. However, there is a possibility of leakage of currents.

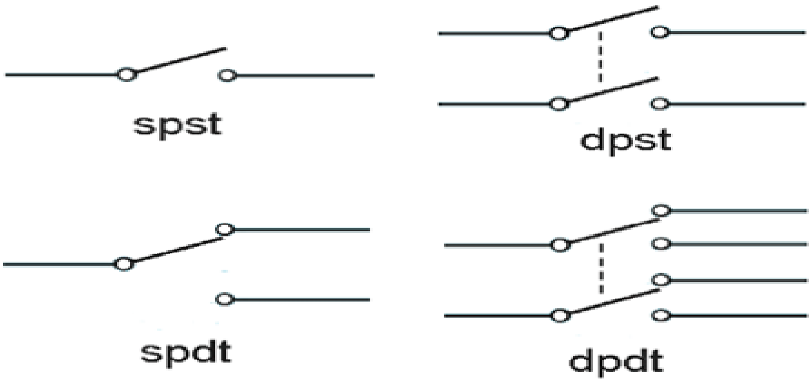


Resistors: An electrical component which resists the amount of current as it goes through a circuit. There are fixed resistors which have their own value and there are also variable resistors which you can change the value. Resistors are probably going to be essential for this project as they are needed for almost all types of circuits.

Sensors: A sensor can detect events / changes in its environment and sends information to other components. Types of sensors include LDR (Light Dependent Resistor), temperature sensors, flow sensors, proximity sensors etc.

LED: A light emitting diode would be useful for displaying a function or event with the project. For example, a light being displayed when there is too much water on a water flow monitor.

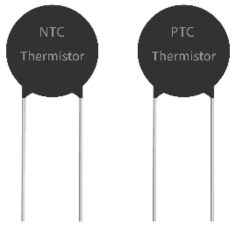
Diode: This electrical component acts as a switch which only allows for one way flow of current. This could be used in projects which need voltage regulation, signal emitters, a switch etc.



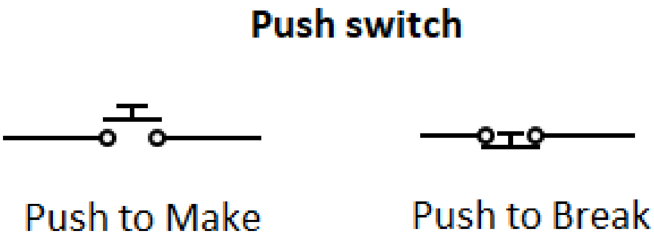
The pole is a moving wire inside a switch that can move to a fixed wire to create a closed circuit. The throw is the fixed contact point that the pole can connect to.

Variable Resistor: This component is like a normal resistor but can have the resistance adjusted. This could be used to dim lights, slow down motors or turn the volume of a radio up. This could be good for a project where I need a variable to change but isn't necessary for many other purposes.

Thermistor: This device converts a physical single which is heat and converts it into an electrical signal. This would be useful for a device that needs to measure temperature levels.



Push Button Switch: This is either a push to make or a push to break switch. A push to make switch turns something on when you press it but a push to break turns it off when you press it. This is another type of switch that could be used instead of your regular rocker/slider switch.



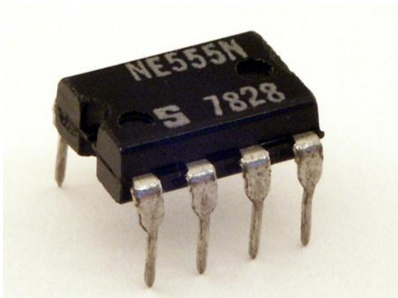
555 Timer: This device is a useful component in modern electronics as it can:

Create a time delay before something happens

Switch something on or off for a specified time

Control the rate of flashing of a bulb

This would be of use for a project that involves a timed circuit for something to happen.



There are many different motor options that could be used for the vehicle, so I had to consider the pros and cons of each one before deciding on the optimal choice.

Motor	Description	Advantages	Disadvantages
Geared DC Motor	Standard DC motor with a gear system to increase torque and reduce speed.	Speed control, High torque output for heavier loads.	Slower speeds compared to other motors, larger and heavier due to gearing system.

Brushed DC Motor	Basic motor that uses brushes and a communicator to switch current direction in the rotor. Operates on low voltage (1.5-6v)	Simple, easy circuit control, inexpensive, low voltage needed.	Wear out of brushes reducing lifespan, electrical noise and friction, less efficient compared to brushless motors.
Brushless DC Motor	Electronic communication rather than brushes.	High efficiency, long lifespan, reduced wear and tear, quiet.	More complex to control, more expensive than brushed motors.
Vibration Motor	DC motor with unbalanced weight attached to shaft, commonly used in phone vibrations.	Compact, lightweight, simple to operate with low voltage.	Not useful in rotational motion (wheels), low power with little torque output.
Servo Motor	Compact motor with integrated control circuit and gearing.	Precise position control, high torque, energy efficient.	More complex than DC motor, limited to range of motion (180 degrees), expensive.
Stepper Motor	Moves in precise steps, highly accurate positioning.	Highly precise movement and can hold position.	Complicated, requires constant power, less speed and torque.

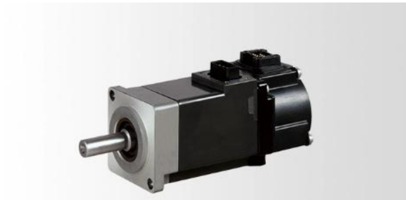
After reviewing the table, I decided to choose a geared motor (1.5v). It provides a balance of torque, energy efficiency and controlled speed, making it ideal for the wheels of the car. Unlike a brushed motor which has fast rotations with low torque, this motor has an internal gear box which reduces speed but greatly increases torque. This was an important choice as I needed to pick a motor that could support the load of the football delivery car all while balancing greater control and smoothness without excessive speed. Even though other options like servo and stepper motors offer precise control, the geared motor balances functionality with practicality for this project.

Geared DC Motor:

Brushed DC Motor:

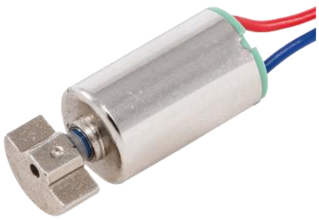
Brushless DC Motor:

Servo Motor:



Stepper Motor:

Vibration Motor:



Different types of mechanisms:

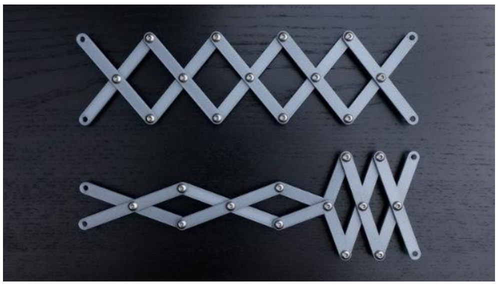
D.C. Motor: A 6-volt TT motor would be good for having any moving parts in a project and does not require a lot of battery power but has low efficiency and can break easily.

Rack and pinion: This mechanism converts rotary motion to linear motion. It would be good for moving parts in a linear motion and would perform well with a motor. It may get stuck however and require lubrication.

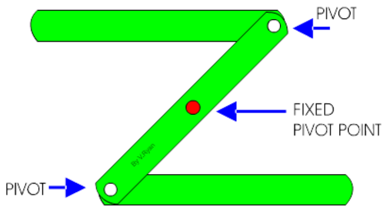
Worm gear system: A worm gear changes the rotational movement by 90 degrees. It is better than a standard gear as it has a high reduction ratio with not much effort but on the other hand may require lubrication because of the worm gear sliding. It may work well with the project as you can directly connect a motor.

Ratchet and Pawl: This mechanism allows rotation in one direction only. It consists of a gear wheel and a stopper. This would be good for projects that need a one direction of rotation mechanism. It also has a relatively low cost and is reliable.

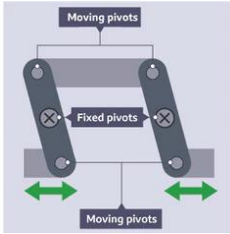
Scissor linkage: This mechanism can create a vertical extension or motion. This could be used for certain types of projects like bins with a push down feature or a movement device.



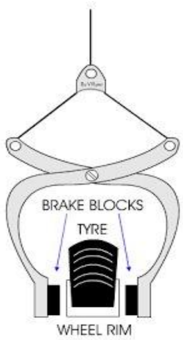
Reverse Motion Linkage: As the top rod moves to the left the bottom rod moves to the right. The direction of movement in one rod is reversed in the other. This is used in practical ways like bicycles.



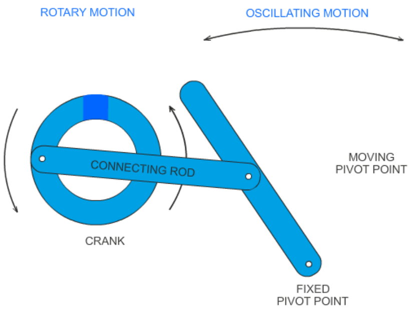
Push Pull Linkage: All rods are parallel to each other in this linkage. As the top rod moves to the left the others move to the right and vice versa. This linkage is used in everyday objects like a toolbox that opens up with parallel drawers.



Bell Crank Linkage: This linkage allows horizontal movement to convert to vertical movement. A practical example includes the brake mechanism on a bicycle.



Treadle Linkage: This converts rotary motion into oscillating motion. It includes a rotary crank on a fixed pivot and a connecting rod joins two moving pivots to another fixed pivot. An example includes the windscreen wipers on a car.



Belt Drives: These are used with pulleys and can be used for conveyor belts, timing belts in cars or bench/pillar drills. There are different types like flat belts, toothed belts, round belts and vee belts.

Bevel gears: These types of gears can change the direction of drive in a gear system by 90 degrees. An example is the mechanism on a hand drill. The handle is turned the vertically, but the gear changes the rotation of the chuck to horizontal.

Chain and Sprocket: This mechanism includes two gears that have a chain rapped around them. This is commonly seen in bicycles for the pedals. Gears driven by chains are used in machinery, motorcycles, car engines etc.

Bearings: A bearing is a component of a machine that allows one part to support another. These are commonly used in machines and vehicles to provide smoother motion and reduce friction.

Modern Materials

Wood:

Wood is split into three categories: Hardwood, manufactured boards, and Softwood. For hardwood, it comes from deciduous trees. Trees that give hardwood have loose leaves, sometimes grow fruit, have broad flat leaves and last 50-100 years. Examples include Beech, Ash, and Oak.

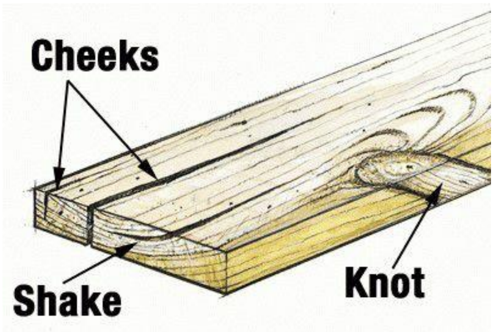
Softwood comes from evergreen trees; they are usually cheap and fast growing. Evergreen trees usually leave cones and needles and last 15-25 years. Examples include Pine and Deal

Manufactured Boards are made from binding or fixing strands or layers of wood together using adhesive. Examples include MDF (Medium Density Fibreboard) and chipboard.

Some of the physical properties of wood include:

1. Quite strong
2. Generally, a good thermal insulator
3. Colour and texture
4. Grain Pattern
5. Workability
6. Structural strength
7. Rigidity vs flexibility

However, there are some problems that may come from using wood in my project. There is no such thing as perfect wood because they all have natural defects like grain, knots, or resin pockets. Wood is also vulnerable to wet rot, dry rot, woodworm splits and shrinkage.



Metal: There are three types of metals, ferrous metals, non-ferrous metals, and alloys.

Ferrous: These metals contain iron. They have good tensile strength, are magnetic, and are usually used in construction. These metals can rust if not treated properly, however. Examples include Stainless Steel and Cast Iron.

Non-ferrous: These metals do not contain iron and are lighter than ferrous metals. They are usually used in the aircraft industry. They are not magnetic and do not rust. Examples include Zinc and Alluminium.

Alloys: This is when two or more metals combine to produce a new material. For example, bronze is a mix of copper and tin. Brass is a mixture of copper and zinc. Alloys can sometimes have hardness and strength along with being corrosion resistant.

Physical properties of metals:

1. Usually Shiny
2. Solid and Strong
3. Dense
4. Have high melting points
5. Conducts heat and sound
6. Ductile
7. Malleable
8. Conducts electricity

Plastics:

Physical properties of plastic:

1. Relatively light
2. Good electrical insulators
3. Non-corrosive, non-toxic
4. Waterproof and washes well
5. Relatively cheap
6. Not biodegradable, not easy to recycle

There are two categories of plastic: Thermoplastics and Thermosetting plastics

Thermoplastic: These types of plastics can be heated and moulded into a shape. They can then be reheated and remoulded into another shape many times. Examples include Nylon, Acrylic, PVC.

Thermosetting: These types of plastics can only be heated once and moulded into another shape. Once set in this shape it cannot be reheated or remoulded. Examples include Epoxt, Resin and melamine.

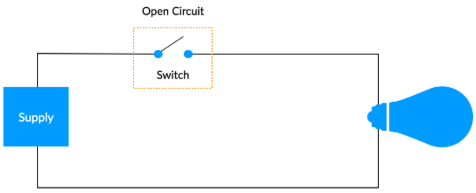
Safety

There are many precautions which must be taken into account with this project so that anybody using it is completely safe while interacting with it.

Sharp edges: No matter what type of material I use for the project, the edges must be filed, sanded, or cut so that people do not cut themselves while using the device.

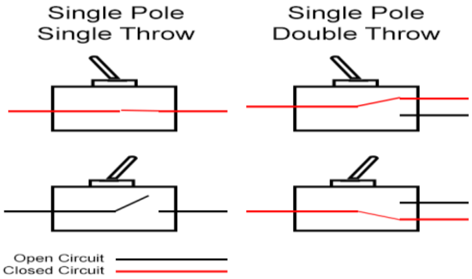
No exposed wires/components: The project should fully case the electrical components and not have anything harmful sticking out which people could get hurt while using the product.

No open circuits: There is a potential for product users to be electrocuted if they come in contact with the open circuit. That means the circuit must be fully closed and checked before letting people use it.



No high voltage: An incident where a person encounters a circuit that has a high voltage rather than a lower voltage can be severe. This is why my project should not exceed a voltage of 12 volts.

Set on/off switch: The product must have an on and off switch that can stop any movement of the project and turn all electrical components off so that no harm can be caused while the project is not in use.



Size

According to the brief the project cannot exceed 500mm in all dimensions. That is 50cm which is still a relatively generous size when measured out.

I do not plan to use all 500mm with my project and will try to keep it to a size where all the electronics can fit inside neatly, and it does not get weighed down by the amount of material being used so that the electromechanical element of the project runs smoothly, and it can move properly.

As I am building an R.C car I believe it will not exceed a dimension of 300-400mm since this is only a model and not the actual car.

If the vehicle is too little, there will not be enough space for all the electronics on the inside such as a Microbit circuit board that connects to the wheels. There will also not be enough space to make the vehicle look like it's in the correct environment.

If the vehicle is too large, the weight of the material will weigh the vehicle down. I believe the wheels of the car will not be able to sustain the downward force of the body of the car, making it difficult to move or causing the car to collapse entirely.

In conclusion the size of my project should not be too small as to not have enough space but cannot be too large either as to contribute to the overall practicality of the car.

Taking everything into account I believe the best size for the project would be between 200-400mm in length, half to three-quarters of that for the with and about the same for the height.

Environment

This refers to what environment my project would fit into. The project I make should align with the environment it is supposed to be in.

For my football delivery car that promotes clean energy, it has to have different factors applied to it in order to make it fit into its surroundings and supposed environment.

Customisation via branding: I can customise the vehicle with club/team logos, along with painting it the colours that the team wears. Along with this, adding different slogans that promote clean energy can add a promotional and functional aspect to the project while fitting it into its environment.

Speed and Reliability: If I design the car to look like a sports car, by adding aerodynamic features like a spoiler, it fits into the whole sporty environment. Making it a reliable vehicle helps it to deliver the football quickly and efficiently without disrupting the game.

Enhancing sustainability: As the car is powered by rechargeable batterie to promote clean energy, it will align with the sustainability goals of many stadiums and football clubs. This helps it to fit into the sustainability aspect of its environment.

These are the different ideas I can use to help my remote control football delivery car fit into the environment of stadiums, sports events etc.

Customer

There are many types of customers that would want to purchase/use the R.C. ball car:

Sport event organisers: People who organise professional or amateur football matches may want to add an exciting way to start the match. They can also promote clean energy at the same time.

Professional football clubs/teams: Teams or clubs that want a fun, exciting way to promote their sustainability goals and clean energy use can use the ball car to start the match in a funny way but also deliver the message of saving our planet.

Event planners for special occasions: People who plan large–scale events like the World Cup or the Euros can promote sustainability to people all over the world using this product. The car broadcasted to people all over the world would be a memorable and eye-catching feature.

This product could be used at every match, event, tournament for kids, adults, anybody at all. This is promoting clean energy one kick off at a time.

Cost

There are many things I may have to pay for to build this project, such as materials, electrical components etc.

Motors: The number of motors I will need for the wheels will either be 2 or 4.

Microbit and circuit board: I will only need 1 so that I can wire and code the vehicle.

Acrylic: I will need plastic to make certain parts of the car like the spoiler or the wheels.

Wires: These will be needed to create the circuit.

Rechargeable battery: This is the clean source of energy I will use to power the car.

The actual body of the car can be created using computer aided design and printed on the 3D printer in my technology room.

Aesthetic

There are different ways I can make this project aesthetically pleasing.

Smooth, rounded edges: Using a file and sandpaper, I can make the edges rounded and smooth which gives the project a finished look to it.

Coloured acrylic: Depending on what club or team this car will be driving for; the colour of the acrylic should match the colour that the team wears. This will make the car quite eye-catching and vibrant.

Accessories: Adding a spoiler to the back of the car and adding different stickers adds a way to show off different features of the car. The spoiler makes it look like a classic sportscar and different stickers promoting sustainable consumption will catch people's attention.

My brief and specifications

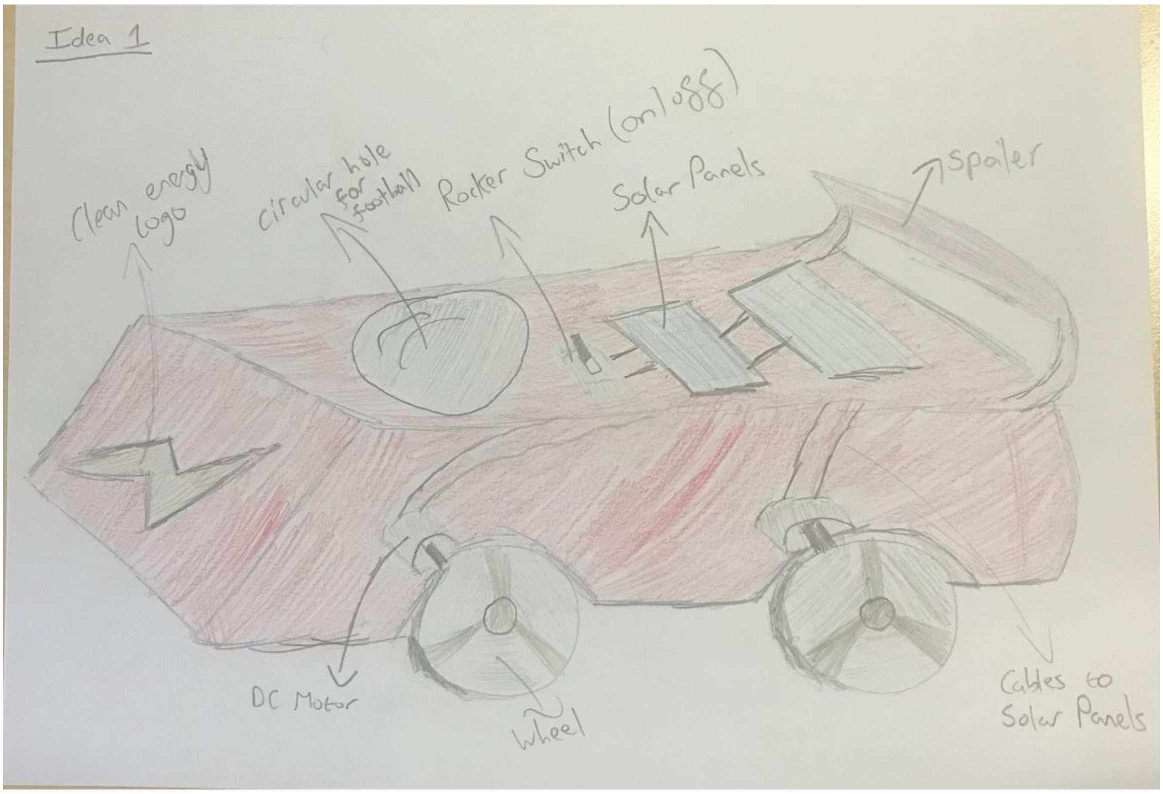
To design and make a race car with a remote control that can deliver the football in a professional football match to the centre of the pitch all while promoting sustainable consumption.

- The device should be able to move via remote control (microbit)
- It should be suitable for event and general use
- The project should be strong, durable and finished to a high standard
- The device should be aesthetically pleasing and well presented
- It must be possible to produce the device from inside the Technology room
- Environmental impact should be considered when selecting materials and components

Design ideas and selection of optimum solutions

For this section, I have come up with 3 different design solutions for the brief. Each solution incorporates a football delivery car that could be used in stadiums as a sustainable consumption promotional product.

Idea 1: Solar Powered football delivery car



In this solution, 2 solar panels are being used to power the motors that allows the car to move. It has a hole at the front of the vehicle where the football will rest. Four motors would be used for this vehicle, one for each wheel. A rocker switch is placed at the top to turn the vehicle on and off. Customers will recognise the logo at the front of the car as it represents the usage of clean energy to power it. The red body will catch attention easily.

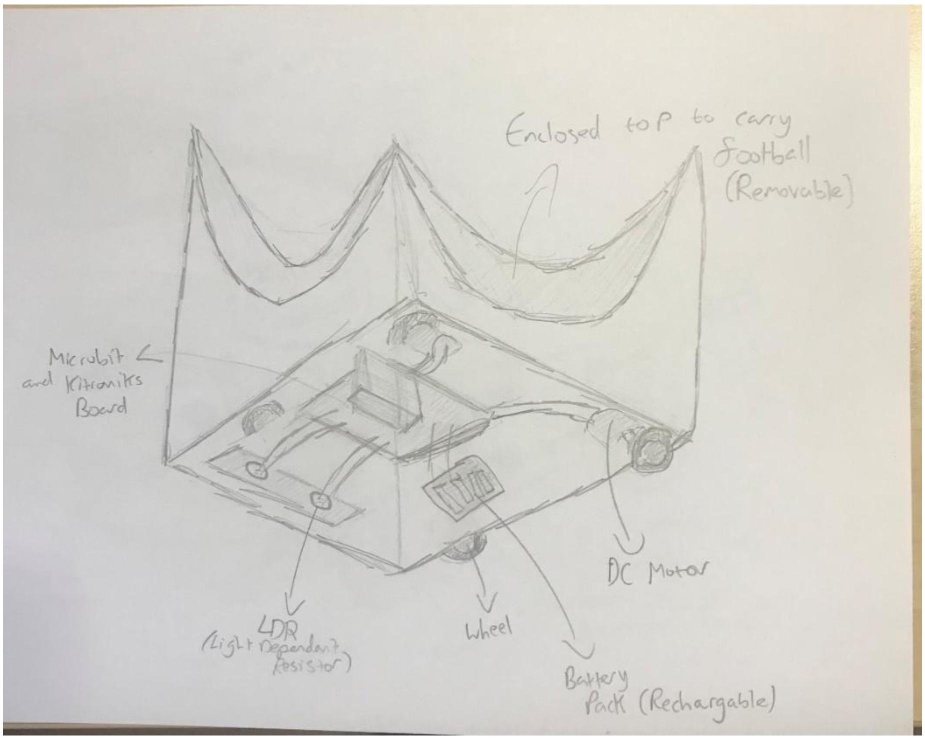
Advantages:

- Clean energy usage from solar panels – directly relates to thematic brief.
- No cost to power it, only sunlight needed.
- Easy to use, no remote control needed.
- Colourful – catches attention easily and sends the sustainability message effectively.

Disadvantages:

- Weather dependant – will not work well on cloudy days or indoors unless artificial light is used.
- Slow power output – solar panels usually provide less power than batteries, car might struggle on rough or inclined surfaces.
- Less control – car can go forward and backwards but can't turn or be controlled properly.

Idea 2: Line/path following football delivery car



In this solution, a box like vehicle with a curved top can hold a football of large size. It is powered by a rechargeable battery which relates to the brief. A Microbit with a Kitroniks board is used to code 2 light dependant resistors and 2 DC motors at the back. The LDRs will track a path on the floor depending on light levels and lines on the pitch etc. This will cause the 2 motors attached to the wheels to make the car go forward and follow the path.

Advantages:

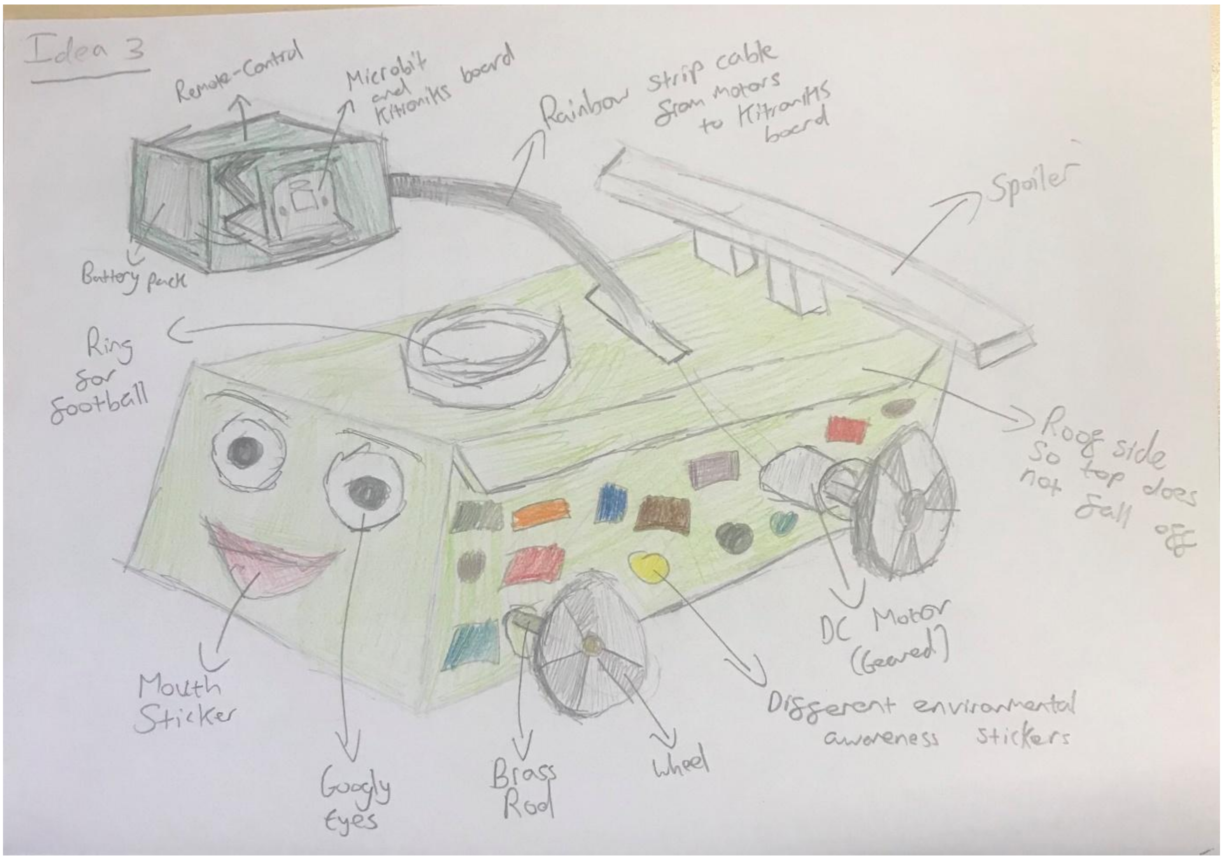
- Automatic – no control needed as it is coded to follow a set path.
- Aesthetic – futuristic robot design gives off a clean and sleek design.
- No human error – since the car is automatic, it will be reliable and minimise mistakes due to human error.

Disadvantages:

- Complicated – the coding will require complex logic, which may be difficult at my experience level of programming.
- Calibration issues – the LDRs need to be precisely calibrated. This may lead to mistakes which will affect the path of the car.

- Limited flexibility – the car is unresponsive to new commands or a changed dynamic in the environment.

Idea 3: Remote control football delivery car



The final solution involves a football delivery car that is remote control. It has a ring on the top to carry the football. It is powered by AA batteries and a BBC Microbit. It is controlled via a wire from the Kitroniks board to 2 DC motors connected to the back wheels. There are many environmental stickers on the car to bring awareness to sustainability. The car is controlled by the buttons on the microbit which can be pressed through a window in the front panel of the controller.

Advantages:

- Precise control – there is direct user control with the remote and is perfect for delivering the ball to the pitch and returning efficiently.
- Catches attention – it is very colourful and vibrant, meaning more people will see the car and notice the environmental message of it via the stickers on the side.

- Simple Concept – I feel this design would be easier to manufacture than the other 2, as there are less coding or electronic complications.

Disadvantages:

- Wire – it can get tangled or damaged from getting caught or tangled. It can cause a possible hazard for the user.
- Limited range – since it is wired, the operator needs to move with the vehicle.
- Power drain – the motors and remote control will consume power quickly, especially during extended periods of usage.

Optimum Solution:

Having considered all three possible solutions, I have decided to choose solution 3, a remote-control football delivery car. I have chosen this idea for the following reasons:

1. It incorporates both electronic and mechanical elements.
2. It fully answers the brief.
3. I have a lot of interest in this particular idea.
4. I think I can make solution 3 to a high level within the time constraints.
5. It is a simple yet very effective solution, especially as a promotional product. It brings light to environmental issues better than the other 2 ideas.
6. It is more engaging and flashier compared to the other 2 solutions.
7. The solution has applications in many scenarios, whether it is a childrens football match or very important matches in large stadiums, for example: The Premier League.

Overall, the design balances creativity and technical understanding, all while offering a strong environmental message and being reliable and fun to operate.

Refining the solution:

Now that I have chosen my idea, I need to refine it and find a suitable design process along with the correct circuits. I feel the use of CAD (Onshape) will be the best design process and a Kitroniks board will keep the circuits and electronics simple but efficient.

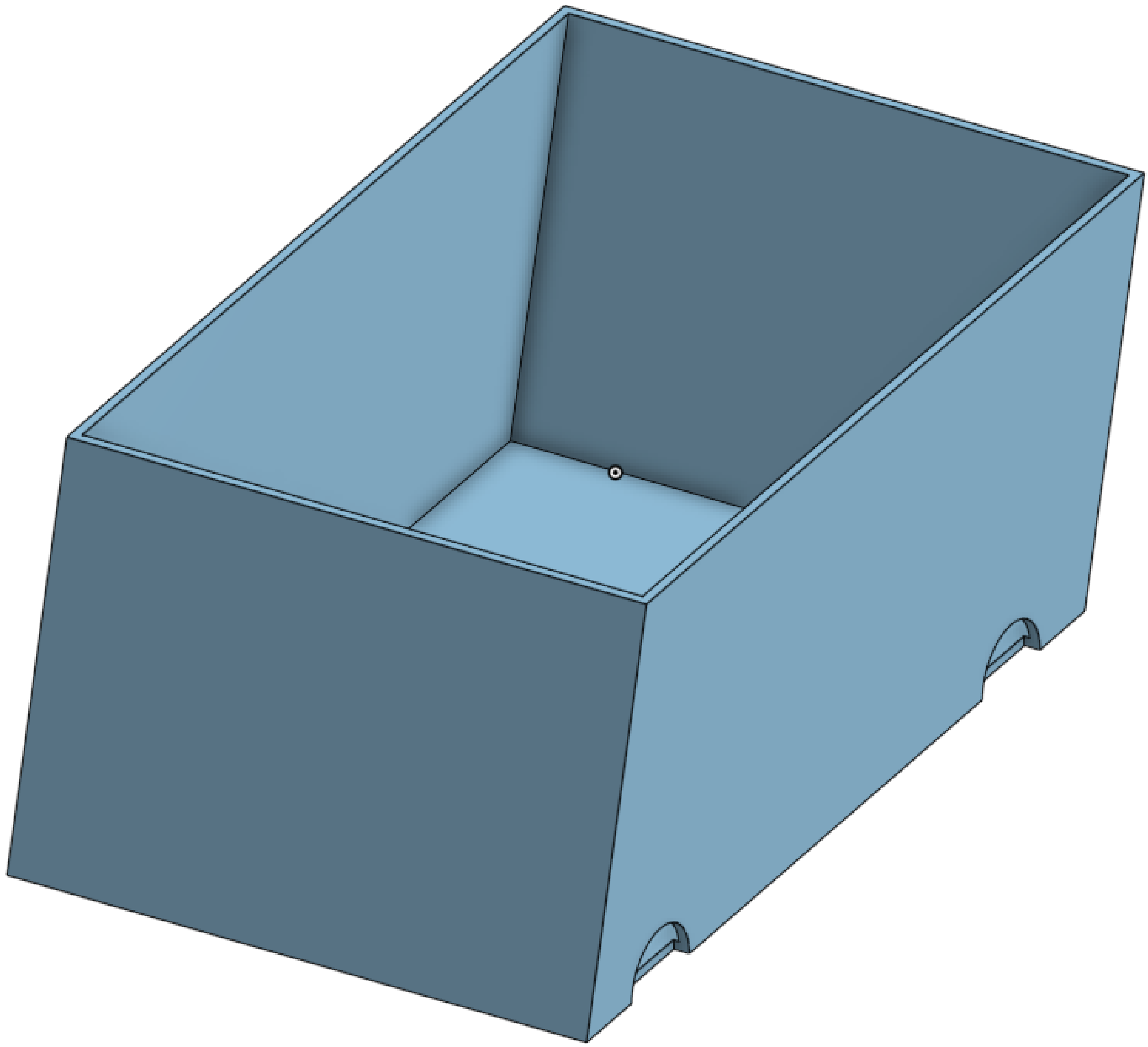
Design Process:

Before I can manufacture parts, I need to design them on CAD and plan the production process.

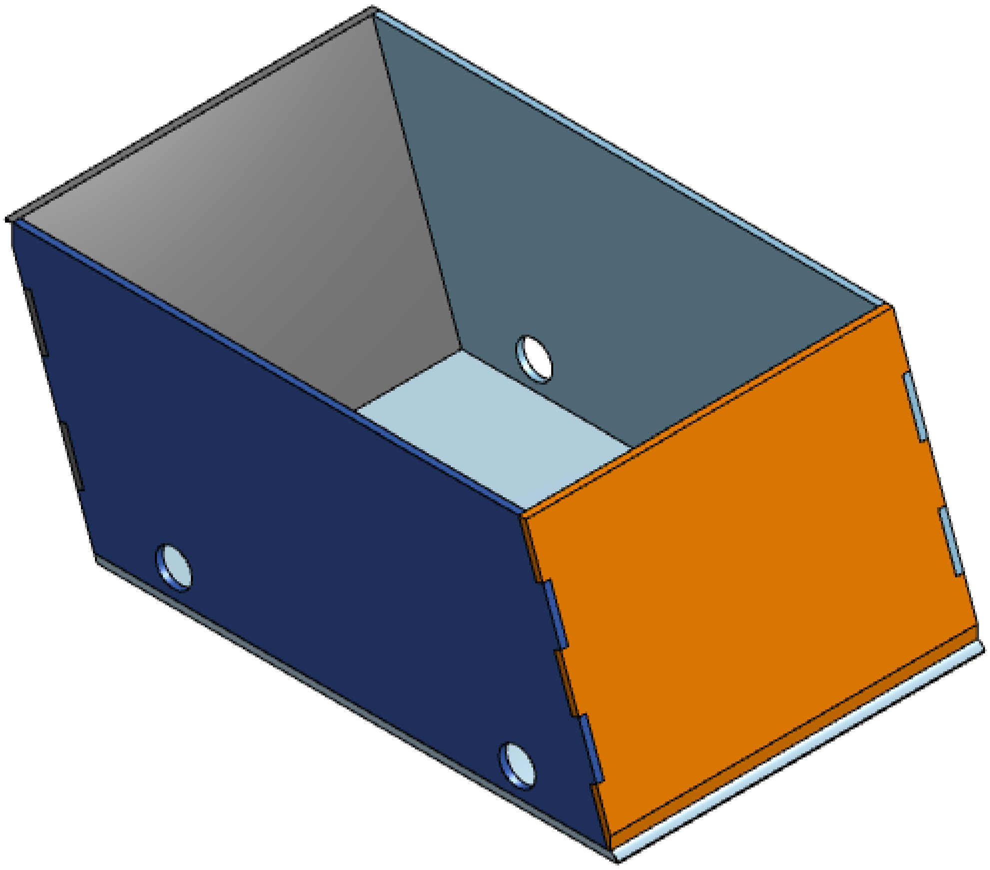
I have made my refined design for the base, roof, remote control and what the base and roof put together will look like:

Base:

My first draft of my base was a reference for what the actual product would look like:

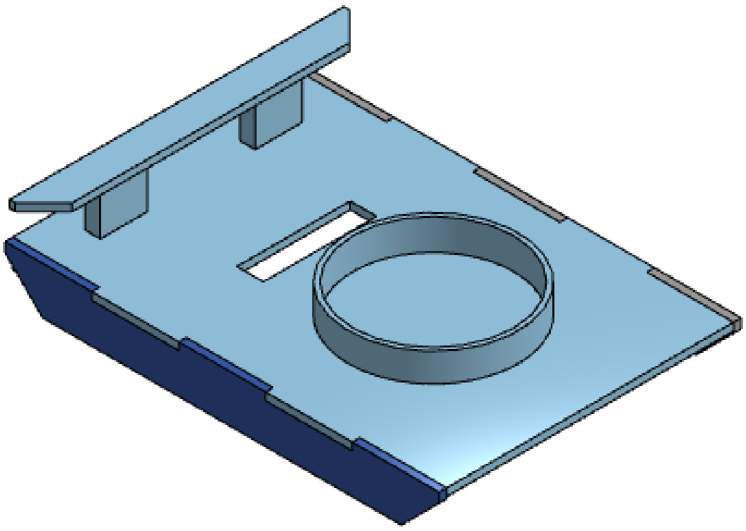


To refine this base, I added in laser joints and properly made holes that would easily fit the motors and brass bar:



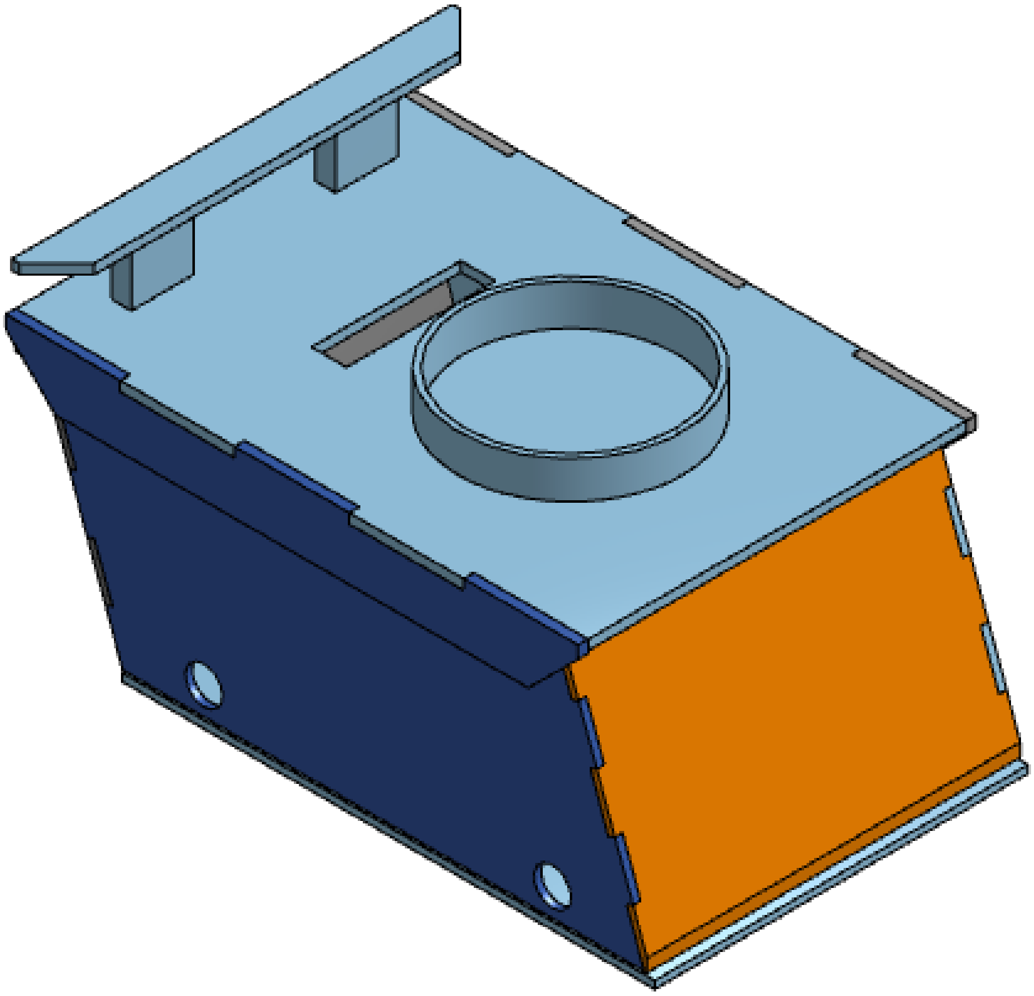
Each part of the base will be joined via a laser joint. This can be precisely cut using the laser cutter. The holes in each side will be for the metal bar and motors to attach the wheels to. I will probably use green acrylic for each part and glue them together using weld on cement for acrylic.

Roof:



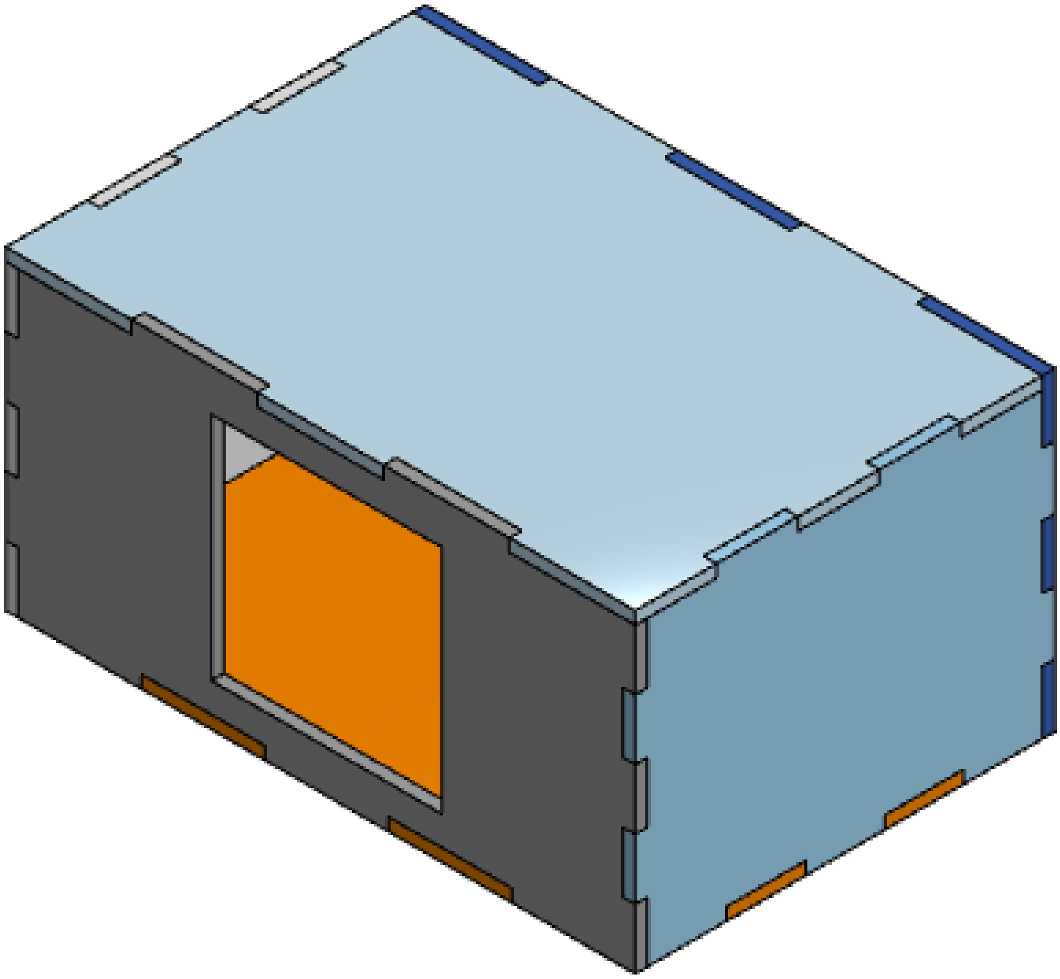
The base of the roof will have an incision where the rainbow strip cable can go through. It will be welded to 2 roof sides that will stop the roof from slipping off. The spoiler and ring will probably be 3D printed as it will accurately produce the parts and lend less to human error if I was to produce it by hand.

Base and Roof:



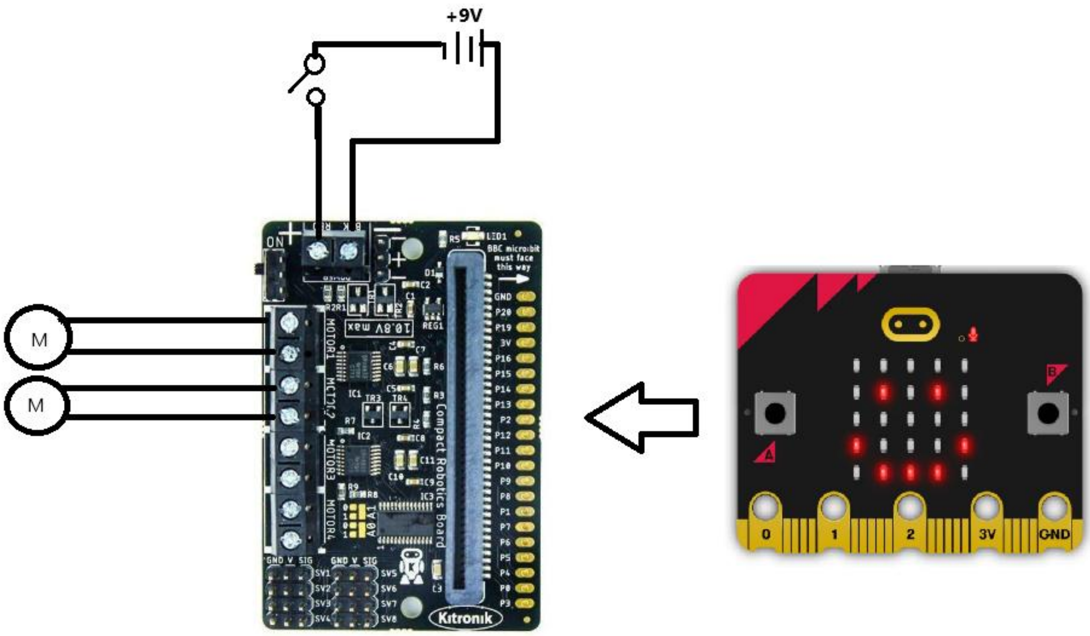
The use of the back and sides of the roof allow for it to rest on the base without slipping off easily. This will help to carry the football efficiently. The weld on process will make the base strong and sturdy, good enough to carry the weight of the roof and the football. There will be enough space within the body of the car to carry as little or as much cable slack as possible, depending on the person using the project.

Remote Control:



All different parts will be welded together to form this box shape. Inside, the bottom panel will have a hole so that the Kitroniks board and battery pack can slip through. The top panel will be removable so that people can turn the Kitroniks board on or off and switch batteries from battery pack. I will probably drill holes in the bottom panel so that I can screw the Kitroniks board into place and glue the battery pack to the side wall. The idea of the front window is that people can press the buttons on the microbit to control the car.

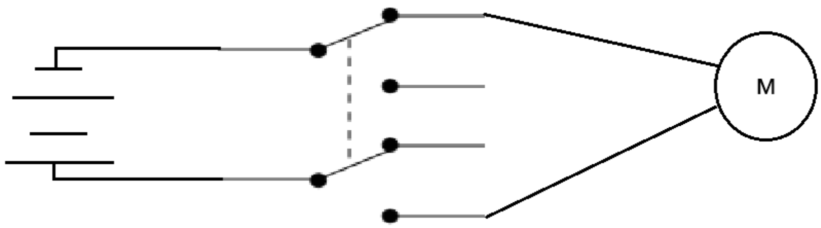
Circuit Diagrams:



This circuit diagram shows how the 2 motors will be connected to the Kitroniks board. The 9-volt battery pack is also connected and can be turned on via the Kitroniks board. The Microbit slips into the board also and is how the car will be coded and remotely controlled.

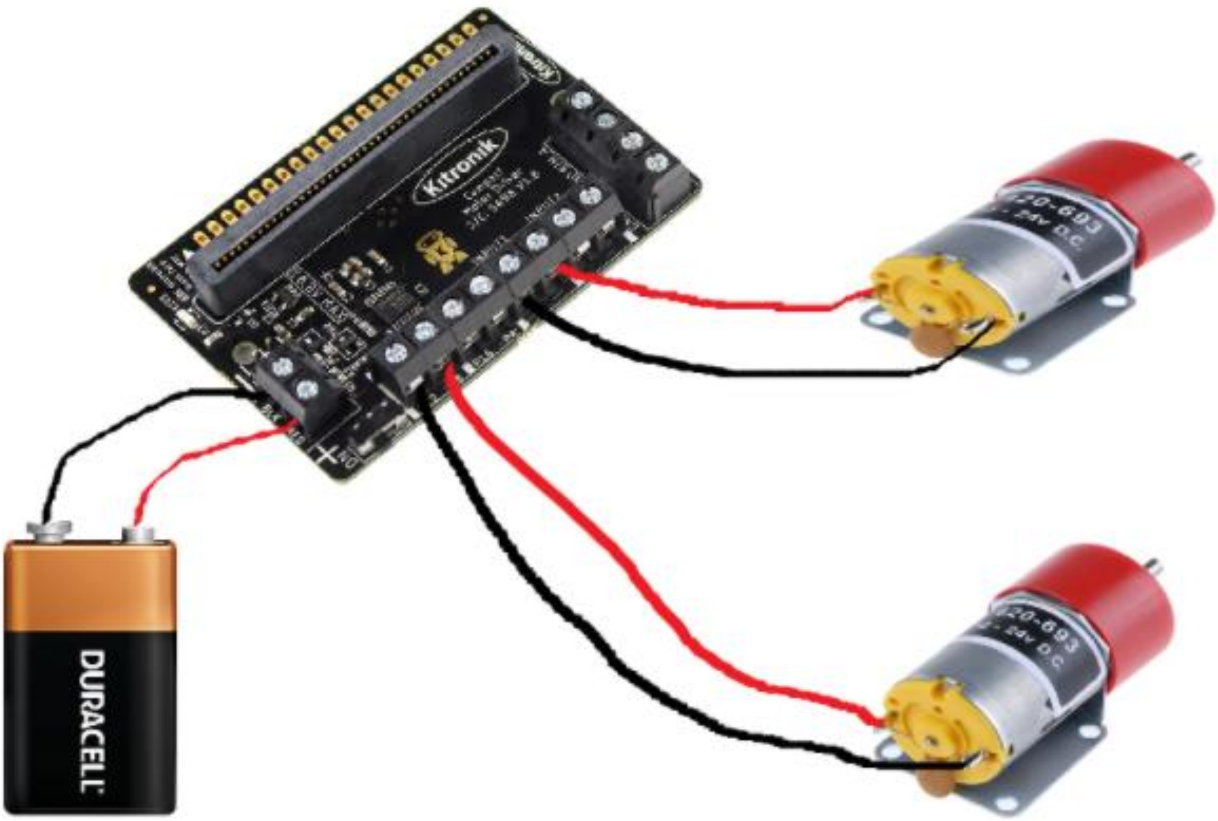
When an input is put through the Microbit such as button input, the code within the Microbit understands the input and sends the code as output to the Robotics board. This sends electricity to the motors telling them what to do like forward speed of 100 or reverse speed 100. If the top logo is pressed, the Microbit relays this to the Kitroniks board stopping all outputs to the motor.

There is also a switch between the 9v battery pack and the Kitroniks board which supplies the entire circuit with electricity. When open the system is turned off and when closed the circuit turns on along with the Microbit.



This is a circuit which runs between the 9v battery and one of the motors. Between them, there is a DPDT switch (Double Pole, Double Throw) which stops current going to the motors when in an idle position. If the switch is put in the up position the current flows to the motor, allowing clockwise motion. If the switch is in the down position, the current is switched and the motor spins in an anticlockwise direction.

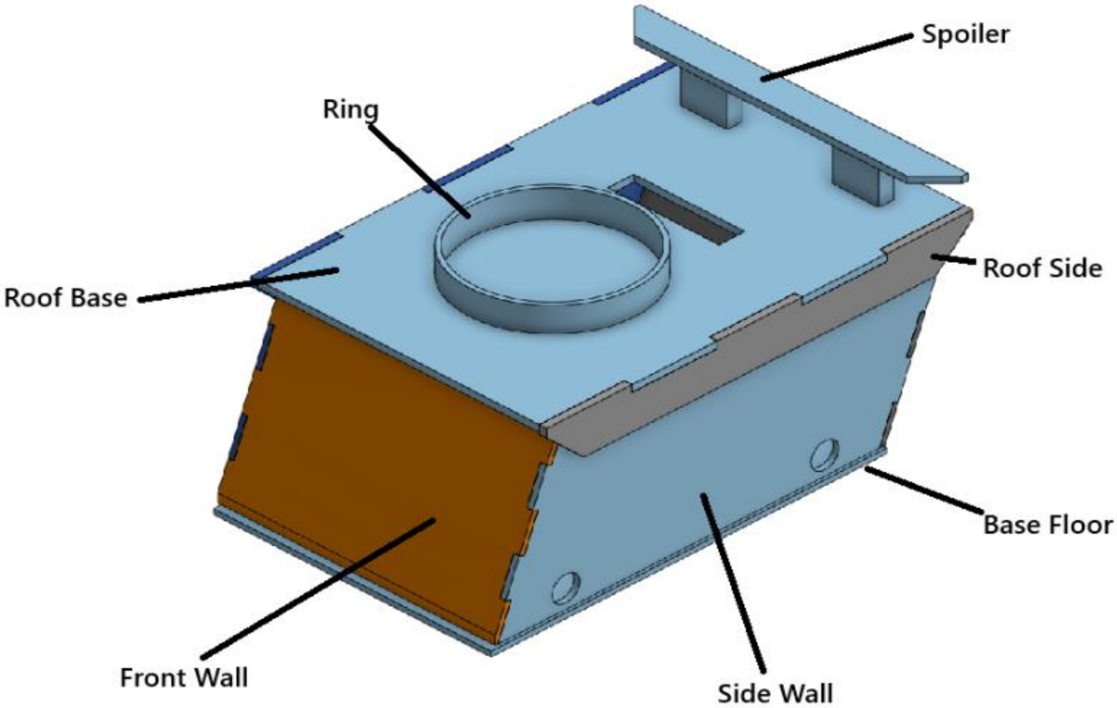
Photo realistic circuitry:

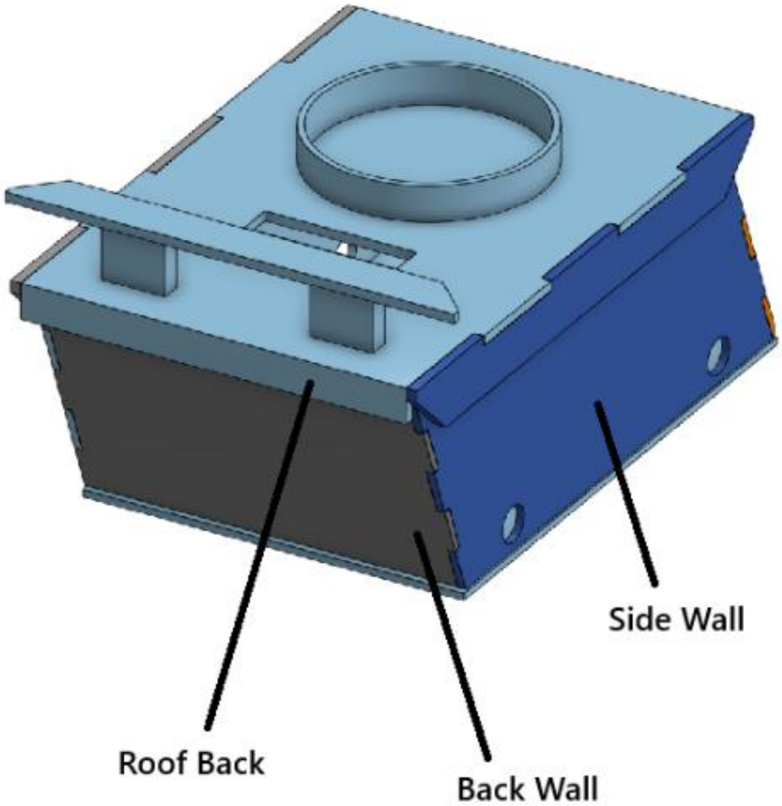


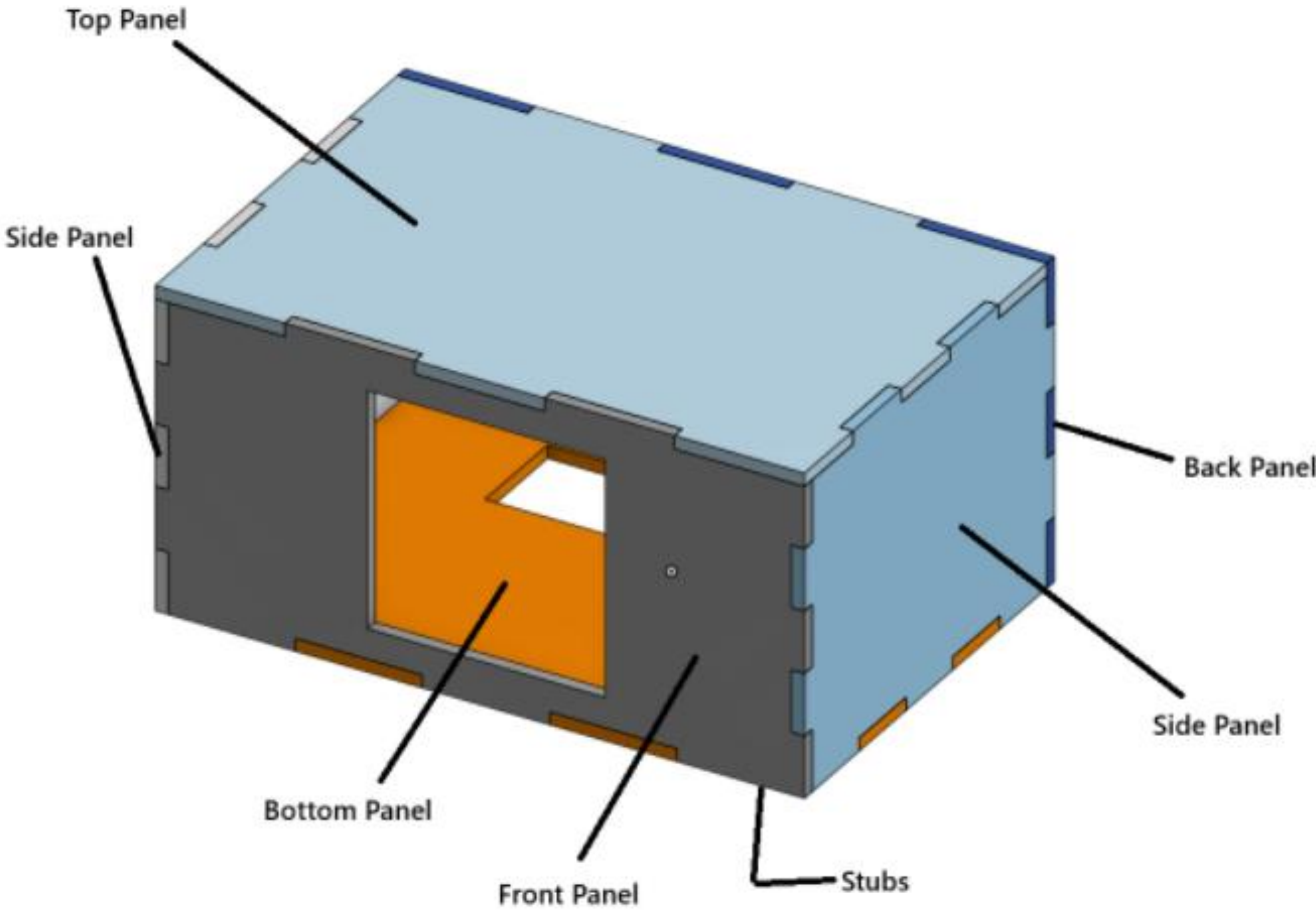
This diagram shows how the cables will be connected to the motors and battery in real life.

The full sketch of my final design:

Sketches and Drawings for Manufacture


Spoiler
Ring
Roof Side
Roof Base
Base Floor
Front Wall
Side Wall

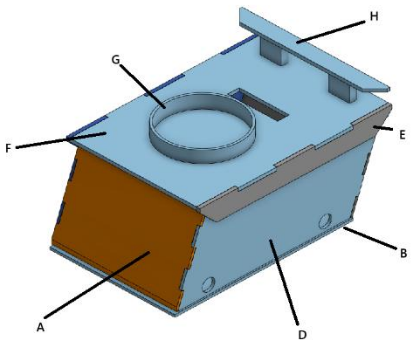

Side Wall
Roof Back
Back Wall

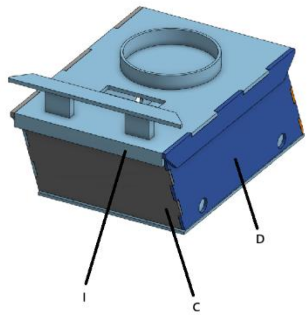

Top Panel
Side Panel
Back Panel
Side Panel
Bottom Panel
Front Panel
Stubs

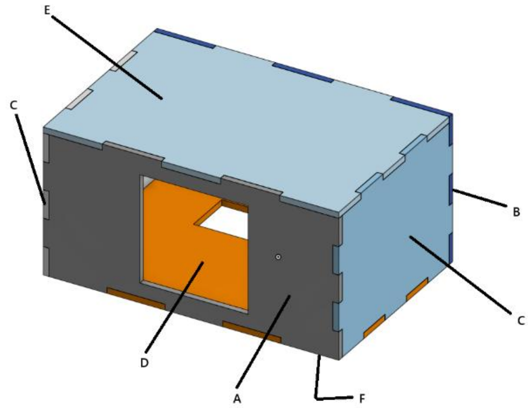
Please refer to secondary display book for all sketches and drawings.

Production Planning

Base, Roof and Controller parts:







The following parts are for the main body of the vehicle:

Part	Part Description	Material	Dimensions (mm) length x width x height
A	Front wall	Acrylic	150 x 106 x 3
B	Base floor	Acrylic	150 x 213 x 3
C	Back wall	Acrylic	150 x 106 x 3
D	Side wall (left and right)	Acrylic	208 x 107 x 3
E	Roof side (left and right)	Acrylic	230 x 25 x 3
F	Roof base	Acrylic	230 x 152 x 3
G	Ring	PLA	86 (diameter) x 15
H	Spoiler	PLA	177 x 18 x 29
I	Roof back	Acrylic	150 x 15 x 3

These parts are for the remote control:

Part	Part Description	Material	Dimensions (mm)
A	Front window	Acrylic	150 x 75 x 3
B	Back panel	Acrylic	150 x 75 x 3
C	Side panel (left and right)	Acrylic	100 x 75 x 3
D	Bottom panel	Acrylic	150 x 100 x 3
E	Top panel	Acrylic	150 x 100 x 3
F	Bottom stubs (x4)	Acrylic	20 x 10 x 5

These are the components required for the electromechanical element:

Component	Quantity
AA batteries	4
D.C. Motor	2
Microbit	1
Kitroniks Board	1

These are the final parts or add-ons needed to finish the project:

Part / Add on	Quantity
Wheel	4
Stickers	20+
Axle (5mm diameter brass rod)	1
M3 panhead screw (M3 X 8mm)	2
M3 hex nut	2

I must plan out how much it will cost to manufacture the project and therefore have created a cost breakdown of the car.

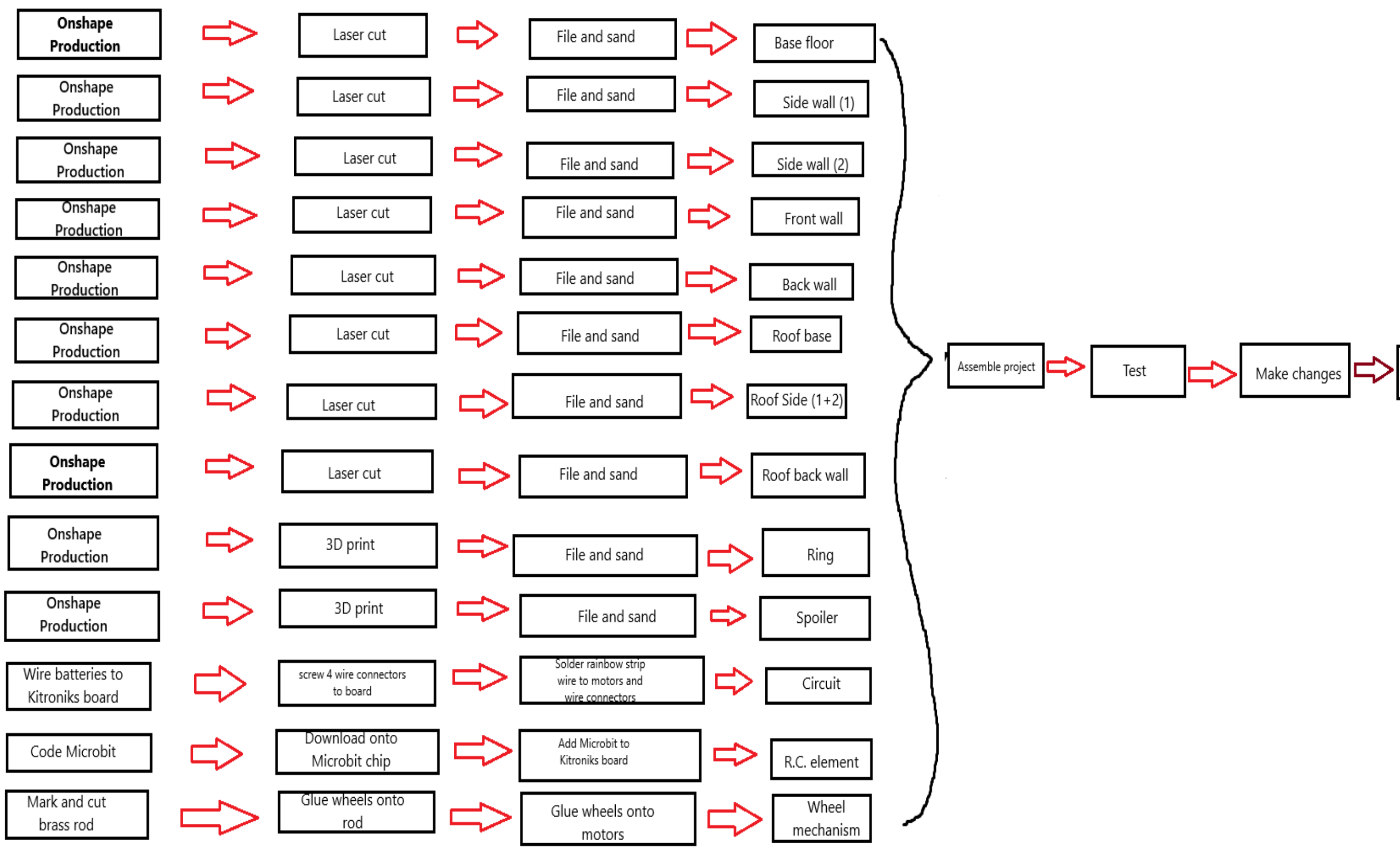
Bill Of Materials (BOM):

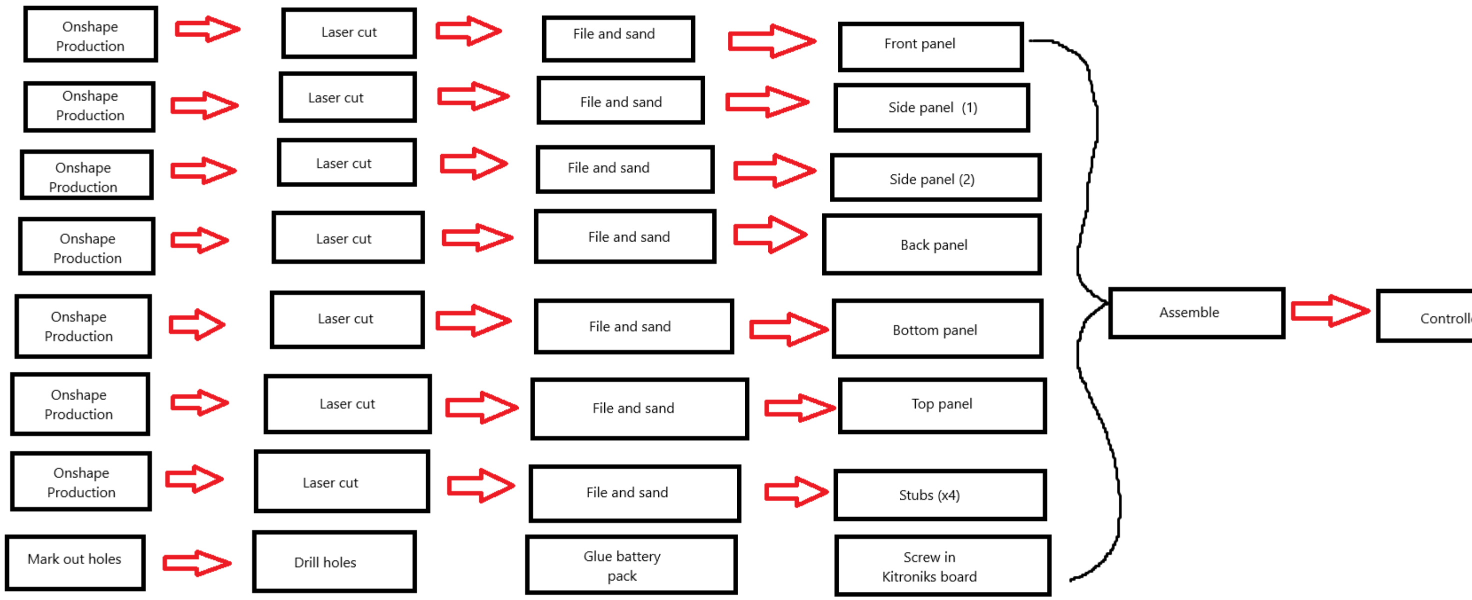
Material / Part	Cost Breakdown
3mm acrylic sheet	€11.50 per sheet (1m x 1.5m)
5mm acrylic sheet	€19.50 per sheet (1m x 1.5m)
1.5v geared DC motor (x2)	€12 per motor - €24
Wires (rainbow strip)	€1.48 for 1m strip
Environmental stickers	€6.65 for 3 packs of 55pcs environmental stickers
PLA filament	€1.10 - calculated based on amount of PLA filament used (~55g)
Kitroniks board	€24.94
BBC Microbit	€22.95
5mm diameter brass rod	€2.00
Wheels (x4)	€3 for set of 4
AA Batteries (x4)	€3.99 for 4 pack
M3 screw (x2)	€2.50
M3 nuts (x2)	€10 (pack of 1000)
Total:	€133.61

I also need to prepare what settings I will use for the laser cutter and 3D printer. In order to minimise time and maximise output all while minimising the environmental impact of these machines, the best settings are as follow:

Laser cutter: 2.4% speed with 95% power.

3D printer: 0.16mm layers, with a 10% infill raft base.


Onshape Production
Laser cut
File and sand
Base floor
Onshape Production
Laser cut
File and sand
Side wall (1)
Onshape Production
Laser cut
File and sand
Side wall (2)
Onshape Production
Laser cut
File and sand
Front wall
Onshape Production
Laser cut
File and sand
Back wall
Onshape Production
Laser cut
File and sand
Roof base
Onshape Production
Laser cut
File and sand
Roof Side (1+2)
Onshape Production
Laser cut
File and sand
Roof back wall
Onshape Production
3D print
File and sand
Ring
Onshape Production
3D print
File and sand
Spoiler
Wire batteries to Kitroniks board
screw 4 wire connectors to board
Solder rainbow strip wire to motors and wire connectors
Circuit
Code Microbit
Download onto Microbit chip
Add Microbit to Kitroniks board
R.C. element
Mark and cut brass rod
Glue wheels onto rod
Glue wheels onto motors
Wheel mechanism
Assemble project
Test
Make changes



Onshape Production
Laser cut
File and sand
Front panel
Onshape Production
Laser cut
File and sand
Side panel (1)
Onshape Production
Laser cut
File and sand
Side panel (2)
Onshape Production
Laser cut
File and sand
Back panel
Onshape Production
Laser cut
File and sand
Bottom panel
Onshape Production
Laser cut
File and sand
Top panel
Onshape Production
Laser cut
File and sand
Stubs (x4)
Mark out holes
Drill holes
Glue battery pack
Screw in Kitroniks board
Assemble
Controll

Structured Assembly Guide:

1. Create all parts on CAD (Onshape).
2. Laser cut base and roof parts using 3mm green acrylic.
3. 3D print roof spoiler and ring.
4. Cut brass rod (5mm diameter) to length of width of the base.
5. Solder a rainbow strip wire to Kitroniks board and solder to two 1.5V geared DC motors.
6. Wire 4 pack AA batteries to Kitroniks board. Insert batteries.
7. Drill hole into the back of the wheels using a 5mm drill bit and a cordless drill.
8. Use weld on cement for plastic to bond the acrylic together and form the base and roof.
9. Glue motors to holes at back of base and fit rod through the holes at the front.
10. Use industrial super glue to glue the wheels onto the brass rod and the motors.
11. Glue the spoiler and the ring to the roof and then fit the roof on the base.
12. Apply environmental stickers to the base and add miniature ball onto the roof.
13. Create code for the R.C. element on the Microbit website.
14. Download code onto Microbit and fit into Kitroniks board.
15. Laser cut parts for the controller.
16. Measure and mark holes for drilling on the bottom panel.
17. Drill holes on the bottom panel using 3mm drill bit.
18. Use weld on cement to form controller box.
19. Glue battery pack to side panel and screw in Kitroniks board into controller.
20. Glue stubs to bottom of controller.
21. Finish by filing and sanding parts of the project until smooth.
22. Project assembled.
23. Test project and make changes, if necessary, then test again.

For scheduling this production, I have created a Gantt chart for the planning of how long each phase of the manufacturing process should take so that I finish the project within the allocated timeframe.

Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Laser Cutting						
3D Printing						
Weld On Cement (base, roof, controller)						
Brass rod, drilling, gluing						
Wiring and soldering electronics						
Assembling Project						
Finishing (stickers, file and sanding)						
Coding						
Testing						

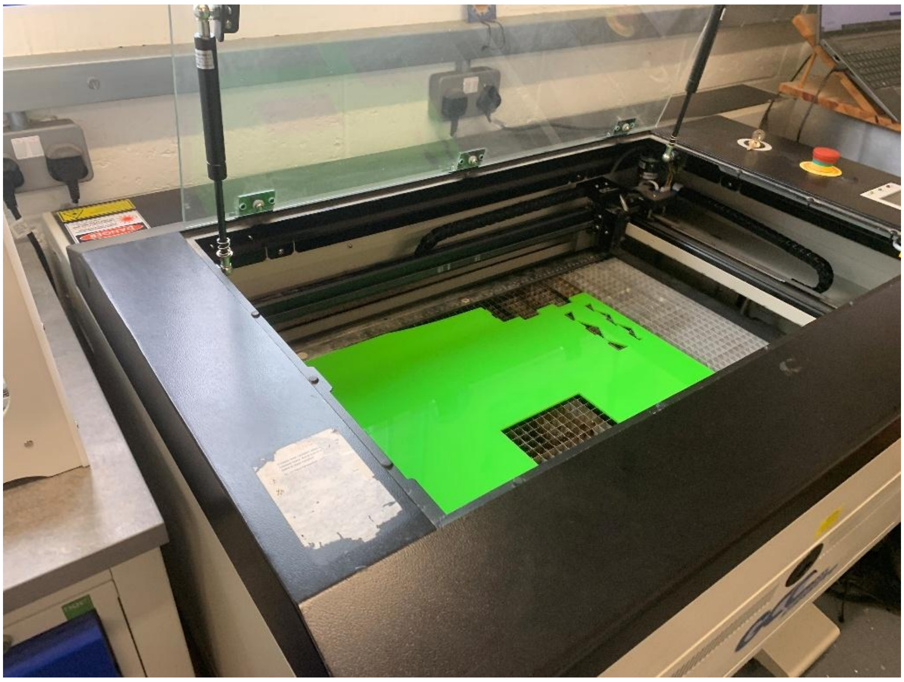
Task dependencies:

- Laser cutting and 3D printing must be completed before weld on cement can be used to form subassemblies.
- Wheels must be prepared, and electronics must be soldered before the project can be assembled.
- The project must be fully finished with stickers, sanding completed etc along with the code for the remote control downloaded onto the microbit before the vehicle can be tested.

Thankfully due to the number of classes I have per week, these tasks can be done in conjunction with each other. For example, the laser cutting could be done in one class and the 3D printing in another, but it is all completed within the same week.

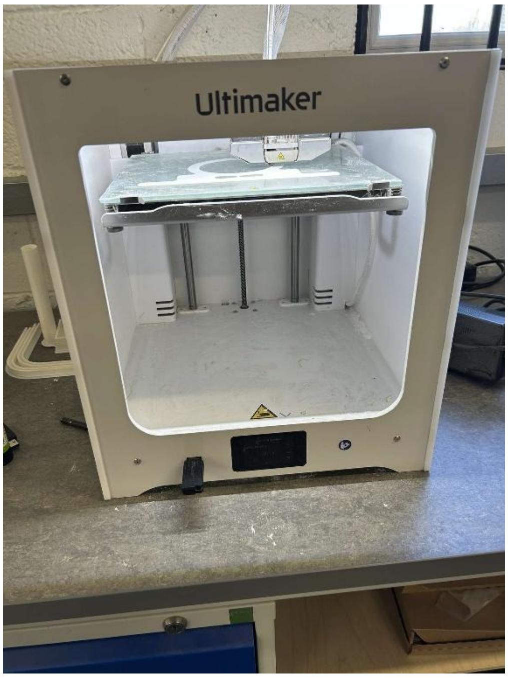
Product Realisation

First, I started the manufacturing process by making the base of the car. Using my Onshape model, I made a drawing sheet for each part of the base. I used the laser cutter to cut out the parts. This was used with 3mm green acrylic. The settings of the laser cutter were 2.4% speed with 95% power. I focused the laser cutter, turned on the



extractor and imported the file of all the drawing sheets to Coraldraw. After the parts were produced, I sanded and filed each one until smooth.

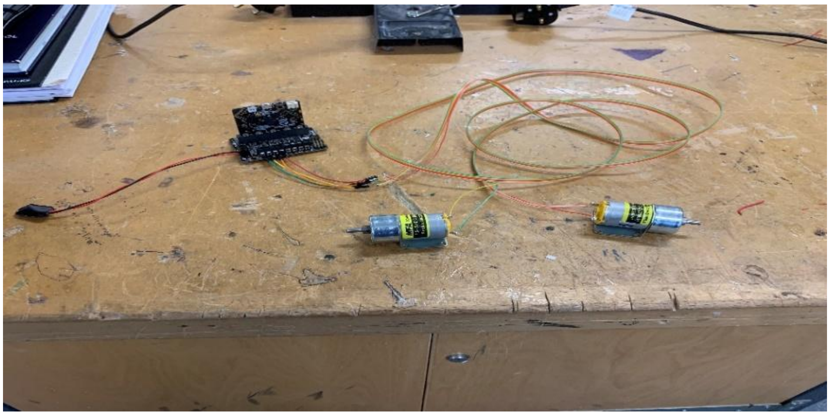
Next, I 3D printed my spoiler and ring. I set the 3D printer to 10% infill raft base and 0.16mm layers. The print time was approximately 4 hours and 30 minutes. I downloaded my Onshape file onto a USB and plugged it into the 3D printer. I then used glue to stabilise the base of the printer and started the print. Once the parts were produced, I chipped off any excess PLA left on the parts.



I then measured the width of my base using a ruler. I then measured and marked the same length on a 5mm diameter brass rod. I tightly fitted the rod into my clamp and cut

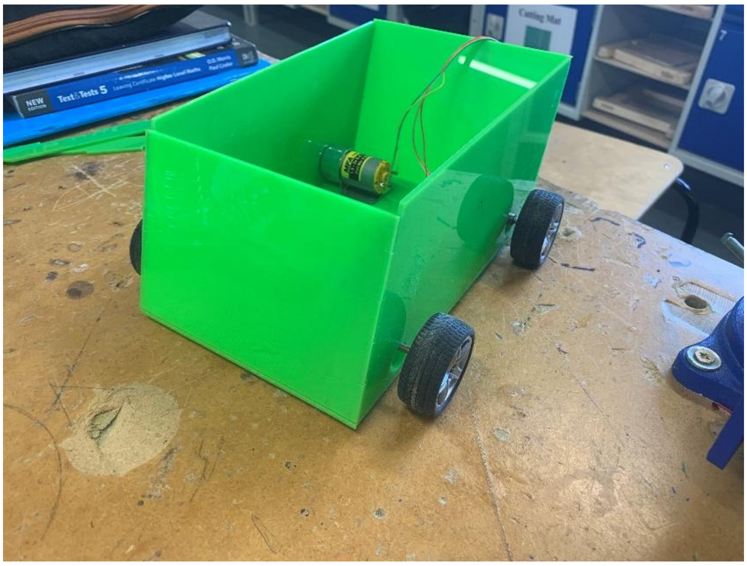
it to the measured length using a junior hacksaw. I made sure each side of the bar was evenly spaced in conjunction with the base.

Next, I started my electronic mechanism. I screwed 4 wire connectors into my Kitroniks board using a screwdriver, and colour coordinated them with a rainbow strip wire. I made sure the rainbow strip was of sufficient length for someone to hold the controller while the car is on the ground and not have any issue with cable length. I then soldered the wire connectors to one end of the rainbow strip and soldered the other end to 2 1.5 volt geared motors. To finish it, I used a screwdriver to screw in the battery pack and inserted 4 AA batteries.



Upon more close inspection of the wheels, I realised they did not have wide enough openings to fit the brass bar and motors. To correct this, I inserted a 5mm diameter drill bit into a cordless drill. I then fitted each wheel into a clamp and drilled into the wheel openings until there was enough space to fit the bar and motors. Unfortunately, for one wheel, the drill bit went too far and came out the other side of the wheel. Thankfully, this did not pose a problem when gluing it to the motor.

To form the shape of the base, I used weld on cement for plastic to bond the base parts together and create the base. To do this, I had to go outside of the tech room with a mask and gloves because the liquid is carcinogenic and irritating to the skin. I then used a syringe to gently apply the weld on to edges between parts. This bonded each part together until the base was formed. This took approximately 5 minutes for each part to be bonded to another. I sanded off any stains of the weld on liquid left after the bonding process.

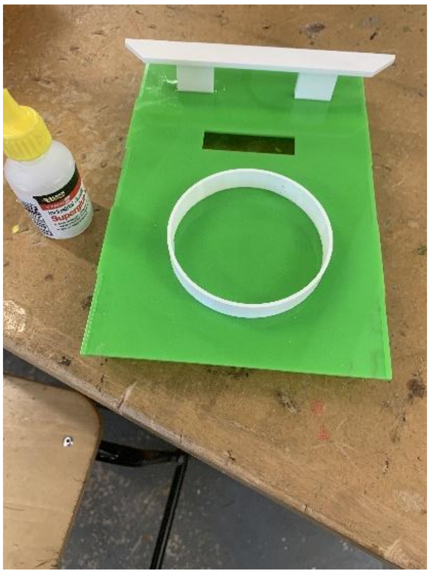


I then started to assemble the project together. First, I glued the motors to the base using industrial superglue. I made sure the motor rod sticked out of the holes in the base and there was enough space to glue the wheels. I then fitted the rod in between the base holes at the front and glued wheels to either side. I glued the other 2 wheels to the back motors.

To further assemble the project, I had to manufacture the roof. This was done by laser cutting the parts I made on my Onshape model. I used the same settings for the base as I did the roof. This was once again 3mm green acrylic. I imported my drawing sheet into Coraldraw, focused the laser cutter, turned on the extractor and started the process. After I went through all the edges and snapped off any residual bits of plastic. I finished by sanding and filing each part until smooth.

Next, I used weld on cement to bond the parts together and form the roof. The syringe greatly helps increase accuracy when applying the weld on and prevent stains on the acrylic. I was once again careful due to the carcinogenic nature of the cement.

To finish producing the roof, I had to glue the 3D printed spoiler and ring to the roof base. I had to make sure they were properly aligned and did not interfere with the slot used let the cable pass through. I carefully used industrial superglue and let the parts set until properly stuck to the roof base. There were stains left due to using too much glue, but I applied some nail polish using a cotton bud to try dissolve lumps and stains as much as possible.



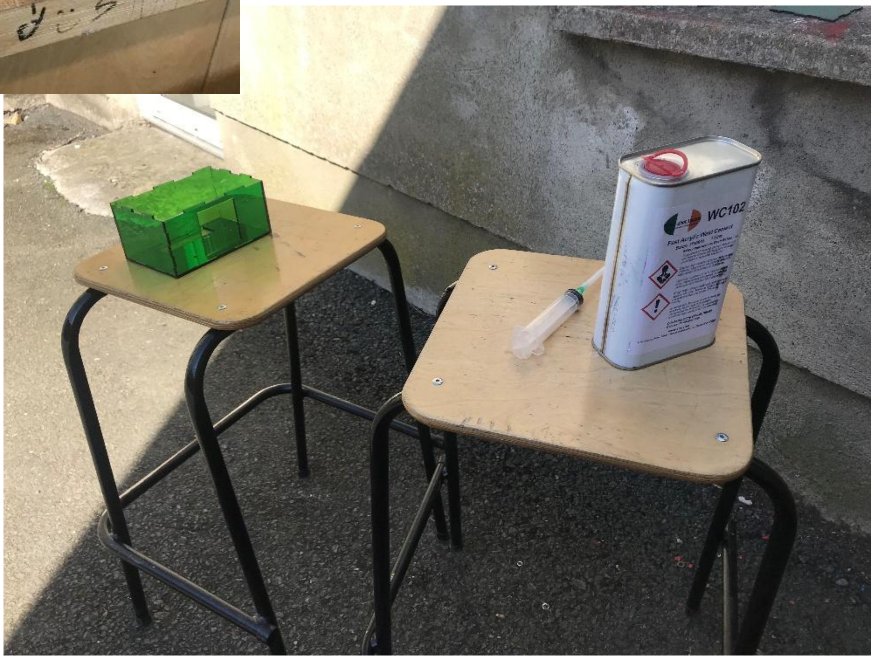
I then started customising my base. This involved ordering 3 packs of 55 stickers per pack. They were a mix of environmental stickers that encourage sustainable consumption and provide awareness to environmental issues. I carefully picked the most relevant and poignant stickers and carefully applied them to all sides of the base, and back. I made sure there were no creases in any stickers, and they were all properly visible. For the front, I used industrial superglue to stick 2 googly eyes and create a silly face that catches attention and add a fun element to the project.

In order to make the remote-control element of the project, I needed to code a BBC microbit and attach it to my Kitroniks board. I decided to use Javascript to code it. After a few days of testing different codes, I came up with the perfect inputs. The motors go forward on button A pressed, reverse on button B pressed. Both buttons pressed simultaneously will turn the vehicle by having one motor go forward and the other backwards. To shut off all inputs, the logo on the microbit must be pressed. I had all inputs show a corresponding LED light on the microbit, for example forward will show an up arrow. A down arrow would show for button B pressed and an alternating ‘S’ for spin would show if both buttons were pressed simultaneously. This code was created on the BBC Microbit website, and I directly downloaded it onto the Microbit by plugging it into my PC. I then slotted the Microbit into my Kitroniks board and tested the code. It managed to work with the following inputs:

```
input.onButtonPressed(Button.A, function () {
    kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor1, kitronik_motor_driver.MotorDirection.Forward, 100)
    kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor2, kitronik_motor_driver.MotorDirection.Forward, 100)
    basic.showLeds(`
        . . # . .
        . # # # .
        # . # . #
        . . # . .
        . . # . .
        `)
})
input.onButtonPressed(Button.B, function () {
    kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor1, kitronik_motor_driver.MotorDirection.Reverse, 100)
    kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor2, kitronik_motor_driver.MotorDirection.Reverse, 100)
    basic.showLeds(`
        . . # . .
        . . # . .
        # . # . #
        . # # # .
        . . # . .
        `)
})
basic.forever(function () {
    if (input.buttonIsPressed(Button.AB)) {
        kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor1, kitronik_motor_driver.MotorDirection.Forward, 100)
        kitronik_motor_driver.motorOn(kitronik_motor_driver.Motors.Motor2, kitronik_motor_driver.MotorDirection.Reverse, 100)
        while (input.buttonIsPressed(Button.AB)) {
            basic.showLeds(`
                . . # . .
                . . . # .
                . # # # .
                . # . . .
                . . # . .
                `)
            basic.pause(100)
            basic.showLeds(`
                . . # . .
                . # . . .
                . # # # .
                . . . # .
                . . # . .
                `)
            basic.pause(100)
        }
    } else {
        kitronik_motor_driver.motorOff(kitronik_motor_driver.Motors.Motor1)
        kitronik_motor_driver.motorOff(kitronik_motor_driver.Motors.Motor2)
        basic.clearScreen()
    }
})
```

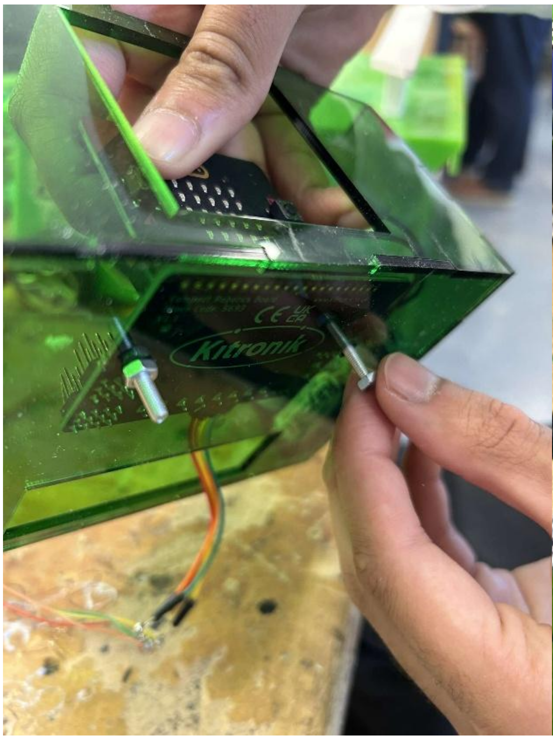
At that point the main body of the project was assembled. All that was left was the controller. I started by laser cutting 3mm dark green see-through acrylic. The same settings were used as before. I imported my Onshape model onto Coraldraw, focused the laser cutter, turned on the extractor and started the machine. I then sanded and filed all the parts once the laser cutting had been completed.

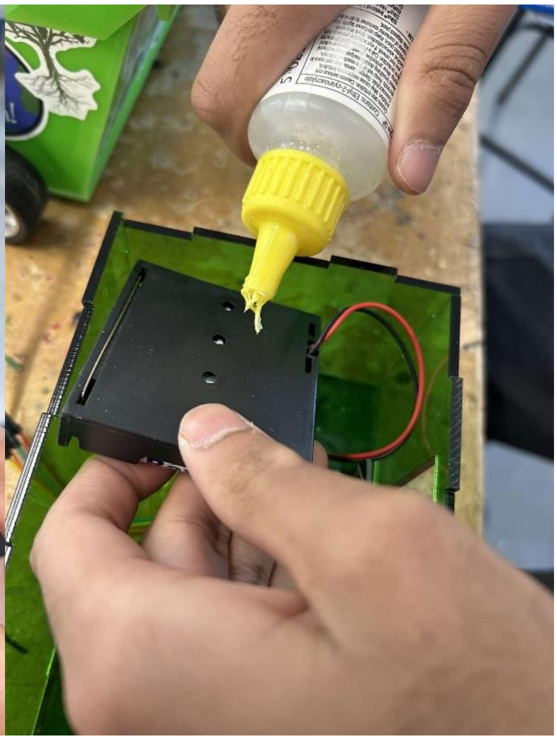
I then marked out on the bottom panel of the controller where the Kitroniks board would sit. I used a 3mm diameter drill bit in a cordless drill to make 2 holes at the marked-out points. This would be where I can use M3 screws and bolts to tightly fasten the Kitroniks board to the controller.



To form the shape of the controller, I used weld on cement again to bond the acrylic pieces together and manufacture the controller box. It was a simpler experience this time and was done much faster due to doing it twice before for the base and roof. This helped to save time and get the project completed within the allocated timeframe.

Next, I finished off the controller by screwing in the Kitroniks board and gluing the battery pack. First, I slotted the Kitroniks board through the opening in the bottom panel. I then used M3 panhead screws (8mm length) and M3 hex nuts to attach the board to the controller. I then used industrial superglue to glue the battery pack to the side panel. I made sure everything was firm and locked in place. I also made sure batteries can be accessible from the battery pack.





I then realised that the rainbow strip cable gets caught when the controller sits on a surface. This could potentially damage the cable. To fix this problem, I decided to manufacture stubs that lift the controller and leave space for the cable to rest and not get pressed down. I did this by laser cutting 5mm white acrylic. This time I had to change the settings for this type of acrylic. I refocused the laser cutter, imported the drawing sheet into Coraldraw, started the extractor and completed the cut. Once finished I snapped off any residual acrylic and sanded the stubs until smooth. I then glued them to the bottom of the controller using industrial superglue and applied nail polish with gloves to remove stains.

The project is now fully assembled. I went through each part of the base, roof, electronics, controller etc, and made sure there were no sharp edges or corners. I filed and sanded any that I found. I tested my car multiple times and fixed any issues that happened. Most were to do with the code or having to re-solder broken wires. The testing made me realise some areas of improvement for the car and alternative ways I could have manufactured the project. Overall, I was happy with how the project turned out.

Testing, Evaluation and Critical Reflection

I am pleased that my project has satisfied the final brief and specifications. The project uses code from a Microbit to power a remote-control football delivery car, the remote being the buttons on the Microbit. The vehicle is littered with stickers, promoting sustainable consumption and catches the eye easily with its colourful body. The project incorporates both a mechanical and electronic system. The project is strong and durable, and finished to a high standard. I manufactured the entire car in the technology classroom during the scheduled times. The use of coloured acrylic gives the vehicle a vibrant look and an appeal to any age group. I believe the project has applications in the real world such as in stadiums, where there will be a guaranteed large crowd of people. This makes a fun and simple way to promote sustainable consumption to a large audience.

I have tested my project in the classroom and found a few areas for improvement or impurities to do with the car. I found that the wheels did not work well on the surface of the floor. This is due to the front axle being too long and not locked in place in line with the back wheels. So, when I started testing the car, the axle would move back and forth, causing the car to turn at unnecessary moments. Another impurity may be that the car does not drive very fast. This may be due to the size of the car weighing it down and reducing speed but also because the wheels are glued directly to the motor. This is a geared motor, creating high torque but also reducing speed.

If I were to do the project again there are a few things I would change. First, I would prioritise the use of gears in the making of the wheel mechanism. I would add gears that lock the front axle in place, forcing it to not rock back and forth during use. Secondly, I would add a gear system from my motors so that I can reduce torque and increase rotational speed. This is done by making a gear train with a high gear ratio. The motors output shaft would be connected to a larger gear which then would be connected to a smaller gear which has the wheel connected to it. For example, a gear with 40 teeth connected to a gear with 20 teeth would double the speed of the wheel. There is a trade-off to this however, as the vehicle must carry the weight of the ball and all other parts. I would have to balance the speed and power when reducing torque. Increasing speed may also cause a loss of control, making it unstable. I would select possible a gear ratio of 1.5:1 or 2:1 to increase the speed.

Another way of improving the wheel mechanism is by using a pulley and belt system. I could have used one motor attached to a pulley which then had a belt around the pulley and the back axle. This way I could have powered the car using only a singular motor. However, I would not be able to implement a turning mechanism like I have on the current version. The solution would also be liable to slip.

I would also make the vehicle smaller, I feel it is too big and carried empty space that is not used for anything. I would design it in less of a box shape and rather like a real commercial car. This could have been done by using the 3D printer more to create a proper car shape.

In order to add to the sustainable consumption aspect of the project, I would use solar panels to power the car. The problem with solar panels is however that it would need a large surface area to be placed on and would require a larger car, therefore using more materials. Therefore, a rechargeable battery seems more reasonable and in line with requirements. The use of 4 AA batteries currently gives an estimated battery life of 5 hours. The rechargeable battery would reduce the waste of batteries and increase reusability of the car. The battery life would improve heavily.

The durability of the vehicle is decent. The use of weld on cement for plastic bonded the acrylic together and created a sturdy base and roof. My use of super glue however was quite messy. I would improve it by using small amounts of super glue and precision to minimise the amount of excess glue on the body of the car. The car’s durability is good; it does not fall apart during driving or break with a minor collision. It can carry the load of a miniature football effectively, but bigger the size, it struggled with the weight increase.

To map all of these observations, I have displayed expected performance vs actual performance of the vehicle.

Category	Expected performance	Actual performance
Battery life	Using 4 AA batteries, I estimated a battery life of approximately 9 hours.	Actual runtime shorter than expected. May be due to high power draw from motors and inefficiencies in the circuit.
Load capacity	Designed to carry a football, I estimated a weight limit of 200g.	Able to carry small football due to high torque from motors and sturdy base.
Manoeuvrability	Expected smooth movement and responsive control from the Microbit, Kitroniks board and 2 motors.	Forward and reverse movement was good, turning difficult due to wheel friction and movement of front axle.
Durability	Expected decent durability, not to break after a few uses.	Good durability, sturdy base and roof.
speed	Based on the chosen 1.5v geared DC motor, I expected the vehicle to reach a speed of 60 or 70cm/s.	Car slower than expected due to low gear ratio in geared motor, friction and wheel traction.
Efficiency	Expected minimal material waste and low energy consumption due to optimised motor efficiency and lightweight structure.	No unexpected energy loss, overheating or material failure noticed.

At the start of this project, I developed a production plan. The plan was useful as it allowed me to get an indication as to how long the project would take to complete. I used my research and also my experience from previous projects to predict the number of classes the project would take. Having looked at the work needed to be completed I predicted that I should be able to finish the project within 24 class periods.

Although I put a lot of work into the plan, I found I needed more time to complete the project. The main reason for the extra time is issues to do with the production of the roof. My original plan was to 3D print the entire roof, including the spoiler and ring. I came to realise that my CAD model of the roof was too big to produce on the 3D printer. I then had to split the roof into 3 parts, the base of the roof (laser cut), the spoiler and the ring (3D printed). I produced each part separately and used super glue to finish the roof. Along with this, my CAD drawings took longer to complete than expected. This is shown on the revised Gantt chart.

I am happy that the production plan helped to stay focused during the production of the project and helped me to complete the project within the designated time and budget constraints.

Time (weeks)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Analysis of thematic brief																										
Overall management of project																										
Research, investigations and specifications																										
Design ideas and selection of solution																										
Sketches and drawings for manufacture																										
Environmental impact																										

Production Planning																										
Product realisation																										
Evaluation and critical reflection																										

Citations and references:

- https://makecode.microbit.org/
- https://www.bbc.co.uk/bitesize
- https://www.youtube.com/watch
- https://www.rte.ie
- https://images.google.com/
- McGrath, D. (2001). *Technology for Leaving Certificate Applied*. Dublin: Gill Education.
- https://www.sciencedirect.com/topics
- https://www.skysports.com/football/story-telling/11095/12928691/future-of-football-climate-sustainability

- https://www.forbes.com/councils/forbesbusinesscouncil/2025/01/16/sports-and-sustainability-putting-people-and-planet-back-into-football/
- https://learn.sparkfun.com/tutorials
- https://www.volkswagen.co.uk/en/life/magazine/tiny-buzz.html