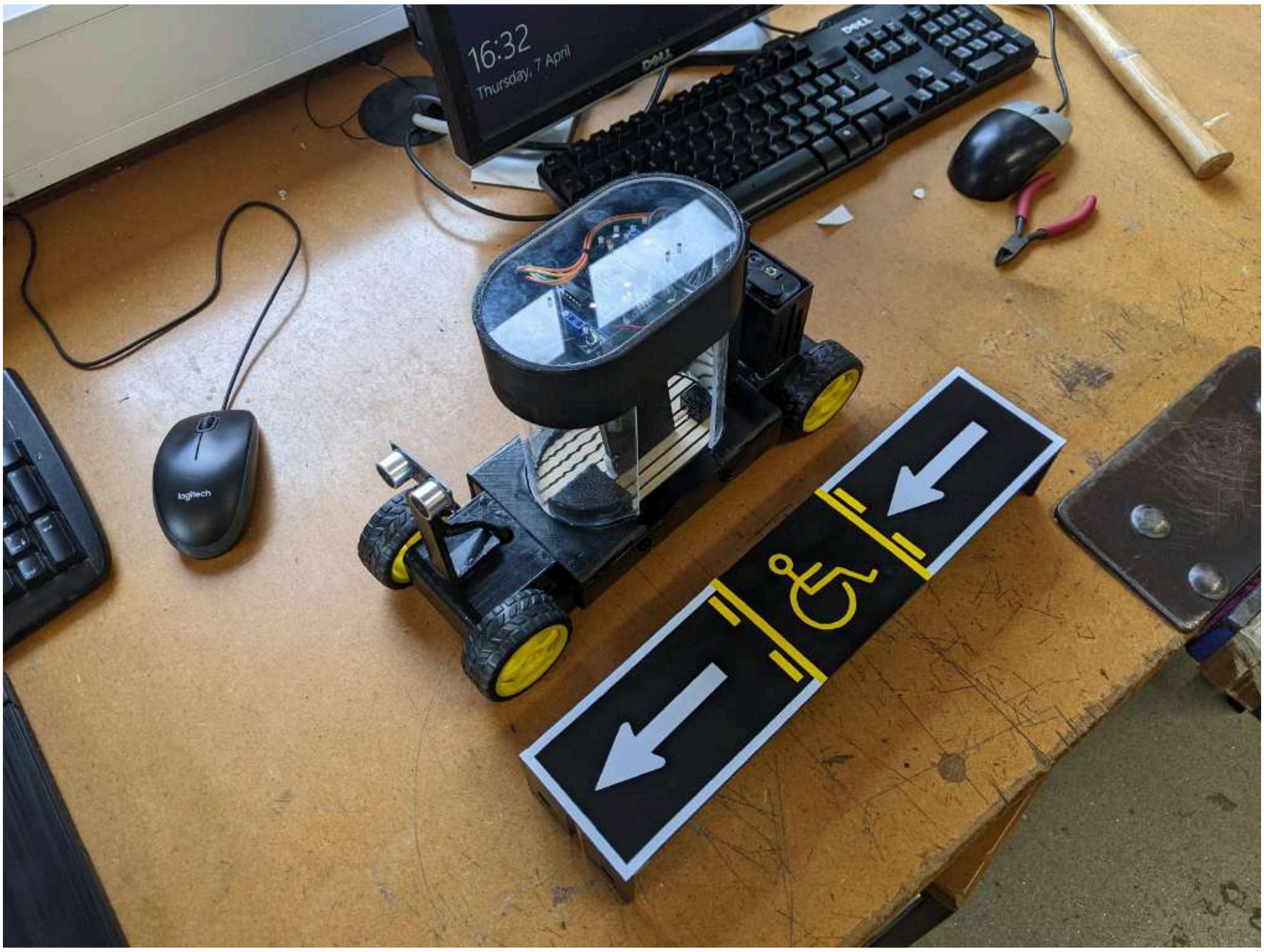
Leaving Cert Technology
2021 - 2022
Project Folio



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1. Analysis of Thematic Brief

The thematic brief for this year's project is as follows:

'The term disability can refer to any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) or interact with the world around them (participation restrictions). It is a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in which he or she lives.'

(Adapted from https://www.cdc.gov/ncbddd/disabilityandhealth/disability.html)

There are many types of disabilities, including, but not limited to, those that affect a person's:

- Vision
- Movement
- Learning
- Communicating
- Hearing
- Social relationships

In this context and with a focus on modern materials and processes, design and manufacture a working model of a device, system or technological aid that could enhance or improve the quality of life of a person with a disability. Your solution should include an electro-mechanical element and should also be well presented.

Note:
The maximum dimensions of the artefact you present for assessment should not exceed 500mm. If multimedia presentations are used to enhance your display, a hard copy printout and a digital file (USB Flash Drive) must be included in your portfolio.

1.1 Research on the Broader Context of the Theme

I shall now carry out some initial research into the main areas in which both technologies and research have led to the development of new innovations and inventions that have aided the disabled user in everyday circumstances under each of the following headings:

- ➔ Activity Limitation
- ➔ Physical/Body Impairment
- ➔ Mind Impairment
- ➔ Participation Restrictions
- ➔ Public Transport/Infrastructure
- ➔ Technological Aids
- ➔ Medical Devices / Systems
- ➔ Independent Living

Before initiating research it's essential and very important to understand the context and to establish what the term 'disability' actually means and to look at 'interaction between the features of a person's body and features of society'.

According to http://nda.ie/disability-overview/definitions/ :

- ➔ The term "disability", in relation to a person, means a substantial restriction in the capacity of the person to carry on a profession, business or occupation in the State or to participate in social or cultural life in the State by reason of an enduring physical, sensory, mental health or intellectual impairment
- ➔ There is no definitive list of conditions that constitute a disability. Any such list could leave out people with significant but rare conditions. There can also be a wide range of differences between how individuals with a particular condition are affected, ranging from mild to severe difficulties.
- ➔ A person's environment, which includes the supports they have and the physical or social barriers they face, influences the scale of the challenges they face in everyday life.

According to the World Health Organization, disability has three dimensions:
https://www.cdc.gov/ncbddd/disabilityandhealth/disability.html

- ➔ Impairment in a person's body structure or function, or mental functioning; examples of impairments include loss of a limb, loss of vision or memory loss.
- ➔ Activity limitation, such as difficulty seeing, hearing, walking, or problem solving.
- ➔ Participation restrictions in normal daily activities, such as working, engaging in social and recreational activities, and obtaining health care and preventive services.

Some key facts about disability:
https://www.afro.who.int/health-topics/disabilities

- ➔ Over a billion people, about 15% of the world's population, have some form of disability.
- ➔ Between 110 million and 190 million adults have significant difficulties in functioning.
- ➔ Rates of disability are increasing due to population ageing and increases in chronic health conditions, among other causes.
- ➔ People with disabilities have less access to health care services and therefore experience less health care needs.

Activity Limitation

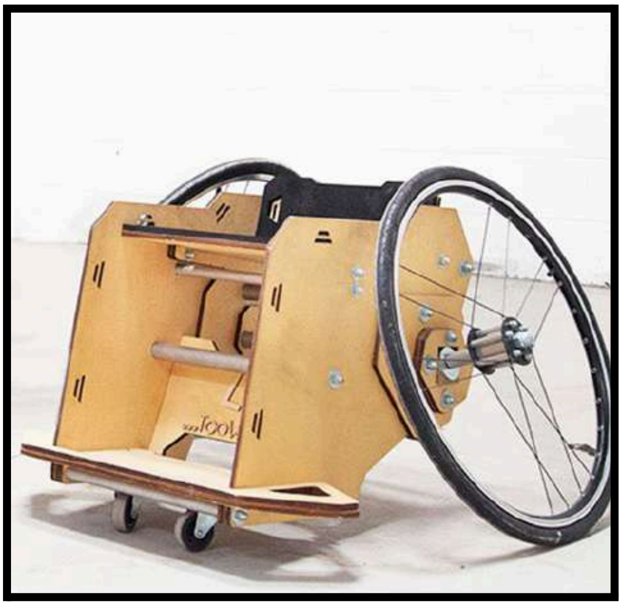
Activity Limitation is defined as a dimension of health/disability capturing long-standing limitations in performing usual activities (due to health problems). Indicators based on this concept can be used to evaluate the general health status, disability and related inequalities and health care needs at the population level. Due to Activity Limitation for disabled users, they are unable to perform daily activities and sometimes restricted to join events etc. However, since technology is rapidly advancing, we still don't have the technology and resources to invent the devices. Examples of Activity Limitation include walking,hearing or doing basic tasks etc. I have researched the area of Activity Limitation and how modern technology can help and have found the following examples:

1. This is SpecialEffect, a product that that modifies game controllers so people with limited activity can use them. This modified controller operated by a combination of the user's lip, voice controllers and a button that responds to the tiny movements of the user's hand. Developed by the company SpecialEffect themselves, a UK-based charity that modifies these controllers making it more easier for the disabled individual and better to play like many others unlike the past when there was limited technology.

   The SpecialEffect controller fits this year's brief since it contains the electro-mechanical element and can and can improve the quality of a person with a disability from performing simple tasks. I could make a PTM Switches mechanism assisted by LDRs where if there is low light from the gestures by the user, it can assist the user to input the controller movements,making it capable for disabled people a role to be involved in.

Sources:
https://www.ft.com/content/ae91d600-8caf-11e7-9580-c651950d3672
https://www.specialeffect.org.uk/

Inputs	Outputs
➔ Toggle Switch to turn on the SpecialEffect System ➔ LDRs to detect low light and gestures ➔ PTM Switches to detect the inputs from the user	➔ A mix of servo and DC motors to move the mechanism so it can feed the data back to the controller ➔ LEDs to show what direction the controller is at ➔ LED to show that the SpecialEffect System is active



2. This is the TooWheel wheelchair, a user-friendly and DIY wheelchair for disabled users who have activity limits on sport and a wide range of areas that requires a lot of work. This wheelchair uses modern technology such as CNC, 3D Printing and various low-cost techniques to make the wheelchair much more affordable and strong enough to support disabled people who cannot afford activity wheelchairs that are around 5,000 euros. Developed by industrial designer Fabrizio Alessio and Polytechnic University of Turin, this wheelchair is open-source and available for anyone in the world that are mostly underdeveloped, giving an opportunity to people who have limited technology and can manufacture this wheelchair with low cost sensors and materials such as plywood, pipes and bicycle wheels to a proper and reliable wheelchair.

   This TooWheels wheelchair fits this year's brief since it includes an electro mechanical element to the product and it can improve the life of a person with a disability. I could make this using low-cost materials and adding sensors that can assist the user, for example as we see here in the first image, the user is in a badminton court, so I could use LDRs and IR Sensors to avoid the user getting outside the court during a game.

Sources:
https://www.ft.com/content/ae91d600-8caf-11e7-9580-c651950d3672
https://toowheels.org/

Inputs	Outputs
➔ Toggle Switch to turn on the TooWheels ➔ PTM Switches to direct the wheelchair if not manually controlled ➔ LDRs to detect if the TooWheels is outside of zone ➔ IR Sensor to detect uneven surfaces or obstacles	➔ Low-cost reliable DC Motors to drive the wheelchair when not manually controlled ➔ LED to show if the TooWheels is on ➔ LEDs to assist the LDRs if it went outside of zone (court)

Physical / Body Impairment

Physical / Body Impairment is defined as the physical/body to move, coordinate actions, or perform physical activities is significantly limited, impaired, or delayed and is exhibited by difficulties in one or more of the following areas: physical and motor tasks; independent movement; performing basic life functions. Ever since the Medieval Ages, the research into aids of Physical / Body Impairment has skyrocketed significantly, especially during the wars (eg. World War I and II) and during the Industrial Revolution. Since many accidents occurred and there was a huge demand for technology aiding the development for disabled users who have physical impairment and difficulty who cannot do basic tasks in everyday circumstances. In modern times, technology is getting better and better to improve the lives of people who have been affected by life-changing accidents. I have researched into the broad area of physical impairment and how it relates to technology and found the following examples that are compatible with the brief :

1. This is the Smart Wheelchair, a futuristic next-gen wheelchair that has an overall minimalistic design and better improvements for the user than modern wheelchairs. Developed by Kookmin University in Seoul, South Korea it allows the user to position the height of the chair to suit their needs and makes it much more comfortable to sit on, reducing the impact of hard surfaces in jagged roads and footpaths. With a maximum capacity weight of 250 kg, this strong and smart wheelchair can automatically adapt and and improve the user by assisting with surfaces that are uneven and allows people to go to places much more easily.

   The Smart Wheelchair fits this year's brief as it contains the electro-mechanical element and can improve the quality of a person with a disability. I could make a self driving model of the smart wheelchair using sensors such as LDRs and DC Motors as outputs to operate the smart wheelchair.

Source: https://ifworlddesignguide.com/entry/74495-smart-wheelchair

Inputs	Outputs
➔ Toggle Switch to start the Smart Wheelchair ➔ PTB Switches to stop / reset its operation in the smart wheelchair ➔ Infrared-Sensor to detect obstacles or uneven surfaces ➔ LDR's	➔ 2 DC Motors to operate the wheelchair that are powerful and stable enough for the user ➔ LEDs to assist the user so he can see ➔ A speaker with a warning sound if the sensors detect a uneven surface that is manually controlled

2. This is the Porta Chair, a portable riser recliner that has a simple and ergonomic design and various improvements for users who have limited physical ability to perform simple tasks, such as sitting or relaxing comfortably. Developed by Recliner Factory Company, it allows the user to position and align the chair to suit their needs and that fits comfortably to their own personal preference. This makes the user comfortable to relax in and can assist the user in many ways, from reading a book to performing daily tasks such as writing,eating etc. With a strong and rigid structure using sustainable materials, the portable riser recliner can be very mobile and can assist the user from assisting for simple tasks turning on the lights and automatically reclining to their preferred position without needing assistance from another individual.

   The Porta Chair fits this year's brief since it supports an electro-mechanical element and can improve the quality of a person with a disability. I could design a model of the portable reclining chair by using DC Motors, Infrared Sensors and LDRs to avoid obstacles.

Source: https://www.reclinerfactory.com/affordable-riser-recliner-chairs/the-porta-chair-mobility-chair/

Inputs	Outputs
➔ Toggle switch to turn on the Portable Recliner ➔ Infrared Sensors to detect uneven surfaces ➔ 2 LDRs to keep the recliner evenly ➔ PTM Switches for easy access from turning on the lamp,and controlling the motors	➔ 2 DC Motors that have a left,right,forward and reverse function (Rear Wheel Drive) ➔ LED to indicate that the recliner is on ➔ LED indicating the battery level ➔ LEDs for a Reading Lamp

Mind Impairment

Mind Impairment is a very complex and broad area where many people define it differently. Some people define it as mental or else by mind. Mind Impairment is defined as a condition in which a part of a person's mind is damaged or is not working properly. Some examples of mind impairment diseases include Alzheimer’s, Motor neurone disease, bipolar disorder,autism, etc. Technology has vastly improved the lives of people with these conditions, one notable example is Intel-built speech recognition system for the late Professor Stephen Hawking, who had motor neuron disease and had difficulty speaking to people. Many of these advancements happen because of the rapid change and ever-evolving progression of new technologies. I have researched the area of Mind Impairment and found the following examples:

1. This is Intel's CTO,an autonomous and AI-assisted wheelchair with a special computer specifically designed for people with motor neuron disease and are unable to speak due to mind impairment and other limitations. A notable example is late Professor Stephen Hawking, who used this personalised wheelchair after Intel assisted him using speech-recognition technology in order to make him have a voice. Developed by Intel themselves and some high ranking experts from around the world, this smart computer can detect letters and other words using motion sensors. These special sensors can detect movement from the muscle in his cheek. Using speech recognition technology, Intel and many high tech companies are developing next generation methods such as using the brain to communicate instead of the muscle, making it much more efficient and easier for the user to speak much faster, reducing the delay of what the user wants to speak.

   The Intel CTO fits this year’s brief since it supports an electro-mechanical element in the computer / wheelchair and it improves the life of a person with a disability. I could design a model using DC Motors,IR Sensor and motion sensors so it can detect movement from the cheek or other muscles so it can operate that function and play a tune or something etc.

Source:
https://www.wired.com/2015/01/intel-gave-stephen-hawking-voice/
https://www.howitworksdaily.com/how-stephen-hawkings-wheelchair-works/

Inputs	Outputs
➔ Toggle Switch to turn on the Intel CTO Model ➔ LDRs to assist the CTO system ➔ IR Sensor to assist the CTO system and avoid unreliable data ➔ Motion sensor to detect movements	➔ DC Motors to assist the mechanism ➔ LEDs to show if the system is on ➔ LEDs to assist the system and to assist the user ➔ Speaker to transmit the data and words from the sensor

2. This is an AR Glass, developed by high tech companies such as Facebook and Google to assist users that have mind impairment and have difficulty speaking or reading due to diseases such as Alzheimer’s and schizophrenia. These high tech AR systems use electrode sensors and multiple cameras and quantum mechanics to understand the surrounding environment and to transmit the information to the user and the user can transmit the information back from their brain using speech recognition technology in order to get a response. Using AI-Assisted technology and multiple sensors and cameras,this can make it much easier and faster for the user to understand and talk to an individual in everyday circumstances. Products that are currently available include Google Glass,Google MindRDR and in the second picture is Facebook’s AR brain reading assistant. (which currently not in development)

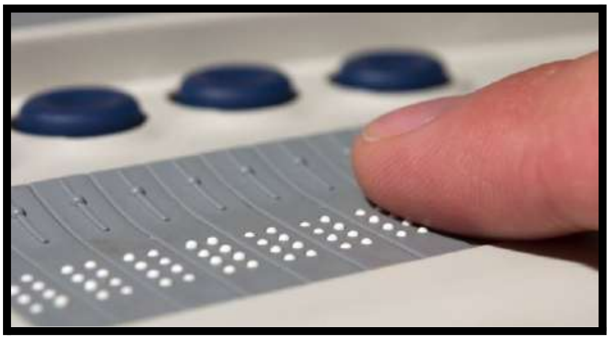
   This AR Glass fits this year’s brief since it contains an electro-mechanical element and can improve the quality of an individual with a disability. I could design a model using a combination of LDRs,electrode sensors,IR Sensors and PTM Switches so it can transmit movement and translate to letters or sounds,using the small gestures from the head.

Sources:
https://www.itpro.co.uk/mobile/22687/google-glass-mindrdr-app-does-it-work
https://www.theverge.com/2019/7/30/20747483/facebook-ucsf-brain-computer-interface-typing-speech-recognition-experiment

Inputs	Outputs
➔ Toggle Switch to turn on the AR System ➔ LDRs to detect low light, inputted by the gestures from the brain using pressure from the muscle ➔ Cameras to detect it accurately and assisting the user of the surrounding environment	➔ LEDs to indicate if the System is on ➔ Stationary LEDs to assist the user in low light conditions ➔ Small speakers stationed near the ears to assist using voice recognition technology ➔ Hologram Screen to assist the user in what they need etc.

Participant Restrictions

Many individuals who have limited physical and mental ability are restricted to participate in occasional activities or jobs in general. Participant Restrictions is defined as a lack of ability from an individual to do everyday tasks such as working on the computer. Notable examples in everyday circumstances include office work and involvement in many other activities that require some physical activity to do so. Modern technology has assisted many individuals with limited mobility and ability to participate in the things they love, for example playing games and hobbies involving practical work. I have researched the open areas of Participant Restrictions and how it can assist disabled users with limited ability and found the following examples:



1. This is the Braille-assisted keyboard and display that enables blind users who have the lack of eyesight to do everyday tasks and participate in workplaces without being restricted. It is operated by a set of keys that have Braille language integrated into them so the user can touch and input the keys required in workplaces and can complete their tasks and communicate with other people. Developed and invested by local governments and high tech companies, this technology enables individuals with disabilities to participate in places where in the past with limited ability, they were restricted to work in that area. Products such as the Brailliant BI 40X braille display and many others are available and affordable to users who are now capable of doing their job, making their lives easier and capable of doing the same task as ordinary people.

This Braille-assisted display and keyboard fits this year's brief since it has an electro-mechanical element and it improved the quality of an individual with a disability. I could design a model with a combination of PTM Switches and LDRs to detect movement from the user using their fingers, and by making braille pads that are inscribed so the user can find it easy to type.

Sources:
https://www.irishtimes.com/business/new-technology-enables-disabled-people-to-integrate-into-workplace-1.3473939
https://en.wikipedia.org/wiki/Refreshable_braille_display

Inputs	Outputs
➔ Toggle Switch to turn on the Braille Display System ➔ PTM Switches to input the letters ➔ LDRs to detect that the user has fully covered the key to make it more accurate	➔ LEDs may be used to assist the user,since LEDs give warmth when used, so the user can position it correctly ➔ Speaker to assist if the system is on and can be used to speak out letters so the user knows what they are typing ➔ Small speaker to be used to indicate if its switched on or off

2. This is the handcycle specifically designed for people who have limited ability and were restricted to participate in global events due to limited interest and technology in order to make an ergonomic and comfortable ride. Developed by many companies from across the world such as Honda and many cycling companies, this aims to allow the disabled to participate in activities they did not have in the past.

   Manufacturers and Researchers across the globe used modern technology to design a wheelchair bike that is lightweight,comfortable and ergonomic for the people so they can have a role in participating in global events. Examples of these events include the Paralympics, BMW-Berlin Marathon and many others. Using high-standard materials and various technologies to improve the quality of the cycle, this can give the user a much more comfortable experience.

The smart handcycle fits this year's brief since it includes an electro-mechanical element that can drive the motors for uphill areas and it can vastly improve the quality of a person with a disability. I could design a model that has DC Motors,LDRs and an IR sensor to guide where it's going and assist the individual who can't go uphill due the strength of the hands since they're weaker than the legs.

Sources:
https://worldsmarathons.com/article/wheelchair-training-for-42k-races
https://www.passionatepeople.invacare.eu.com/handcycling-basics-handcycling-right/

Inputs	Outputs
➔ Toggle Switches to turn on the smart handcycle ➔ LDRs to assist the user by aligning itself in the lane, preventing accidents and preventing the lightweight bike going upside down ➔ IR Sensors to avoid obstacles ➔ PTM Switch to turn on the DC Motors to assist the user in uphill areas	➔ 2 DC Motors to assist the user in uphill or uneven terrain since more power is needed ➔ LED to indicate if the system is on and LEDs to state the battery's power ➔ LEDs stationary as indicators if it's needed on public roads

Public Transport / Infrastructure

Public Transport and Infrastructure is an ever-evolving sector where everyday new technologies are being developed to assist many people, ranging from old people to disabled people with limited abilities. Modern technology has assisted many individuals with limited mobility and ability to drive and travel safely without the need of another individual. I have researched the open areas of Public Transport and Infrastructure and how it can assist disabled users with limited ability and found the following examples:

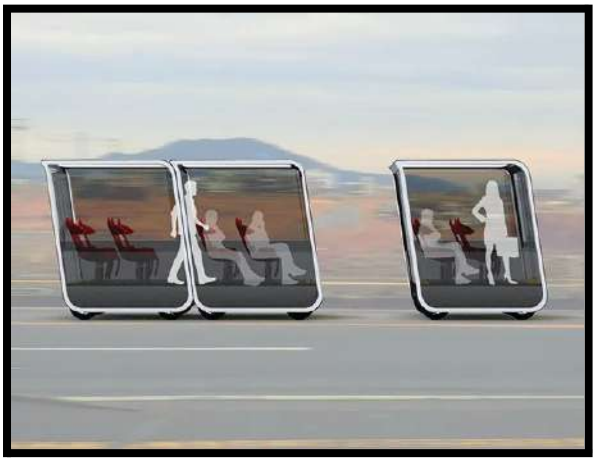
1. This is the VW Sedric Concept, an all-out scheme by Volkswagen to rapidly increase the autonomous systems in Volkswagen cars by 2022. The autonomous world is very competitive, since huge companies such as Apple,Google, Tesla and Uber are racing to create the first ever autonomous vehicle due to this huge market capability and enormous foreign and business investment. All these companies are trying to develop the safest, most sustainable autonomous vehicle that can be integrated into urban city infrastructures and on public roads.

   The autonomous systems would significantly improve and impact the lives of people with a disability and their interactions with society etc. in many ways. These autonomous systems have self-learning capabilities and better feedback that can transmit data back to ecosystem, one such example is the Tesla Ecosystem, where a huge range of cars such as the Model S and the Model 3 share autonomous data of their GPS and their driving, making it much easier for their 'Autopilot' system and making it much better for Tesla themselves to improve the software and make it much more reliable than many others. People with a disability such as visual impairment would be self-sufficient and not have to rely on other people or public transport to bring them to a destination. Eventually all cars will become autonomous, drastically reducing the amount of accidents making it safer for other people. This allows the disabled people to have more freedom and more opportunities for people with disabilities to work in the workforce.

The self-driving car fits this year's brief since it contains an electro-mechanical element and it can improve the quality of a person with a disability. I could design a self-driving car with DC motors,LDRs and with an IR Sensor. I could design a mock racetrack where the self-driving car would follow the track and try to position itself safely as possible.

Sources:
https://www.volkswagenag.com/en/news/2017/03/Autonomous_driving.html
https://www.volkswagen-newsroom.com/en/fully-automated-driving-3633
https://europe.autonews.com/article/20181118/ANE/181119743/vw-aims-to-catch-up-with-waymo-s-headstart-on-autonomous-cars

Inputs	**Outputs**
➔ Toggle Switch to turn on the autonomous system ➔ PTM switch to disable the system if it's an emergency ➔ LDRs to assist the system avoiding out of lane/roads ➔ IR Sensors to avoid obstacles	➔ DC Motors to drive the system ➔ Speaker to alert the driver if it gets too close with another object that could potentially damage the car ➔ LEDs to indicate it's battery, if the system is on and for exterior lighting,making it safer for other drivers



2. These are autonomous pods, a new way of transporting freely and reducing the congestion of cars in cities. With its simple and minimalistic design, these pods are very modular and have long range capabilities, while also very easy to travel in and more freedom capabilities. People who have disabilities would have a lot of advantages with these autonomous pods, since they are self-driven, fully charged all the time, available for personal hire and are found in numerous centres around the local area. This reduces the range-stress anxiety and other factors, making it much easier for people with limited capability to travel and more opportunities to be involved in. Developed by tech companies such as Amazon and Uber, these services make it much more safer and accessible for individuals with a disability without needing the use of timetables and more independence.

The autonomous pod fits this year's brief since it involves an electro-mechanical element and it improves the quality of a person with a disability. I could design a minimalist pod using DC motors and a combination of sensors such as LDRs to assist where it's going. I could design a road with curves and edges to test its capabilities.

Sources:
https://www.techrepublic.com/article/new-autonomous-pods-move-in-swarms-to-improve-public-transportation/
https://www.wired.com/2015/11/this-guy-wants-us-to-commute-in-autonomous-on-demand-pods/

Inputs	**Outputs**
➔ Toggle Switch to turn on the autonomous pod system ➔ PTM Switch to disable the autonomous route if needed in an emergency ➔ LDRs to assist the system in the road ➔ IR Sensor to avoid oncoming obstacles or uneven surfaces	➔ DC Motors that drive the system ➔ LEDs for the exterior for other drivers when indicating and visibility ➔ LEDs to indicate if the system is on and battery health ➔ Speaker so it can say what directions it can go, how many minutes are left to finish the journey, alerts if the system detects an object close to the pod etc.

➔ This is the 'Campus Shuttle' an autonomous vehicle developed and designed by Yanko Design, an international firm partnered with the Reddot and Innovative Design Awards. This autonomous vehicle has many functions, with an on screen display for navigation to an accessibility platform that is also retractable, allowing for users with limited mobility to go on without the need of assistance from another individual.
People who have disabilities would have a lot of advantages with these autonomous pods, since they are self-driven, fully charged all the time, available for personal hire and are found in numerous centres around the local area. This reduces the range-stress anxiety and other factors, making it much easier for people with limited capability to travel and more opportunities to be involved in. I could design a model that is minimalist and that can serve it's purpose by also adding voice-assisted control to make it easier for the user.

Sources:
https://www.yankodesign.com/2021/08/03/this-autonomous-shuttle-bus-reimagines-last-mile-commute-with-informative-graphics-and-a-minimal-transparent-design/

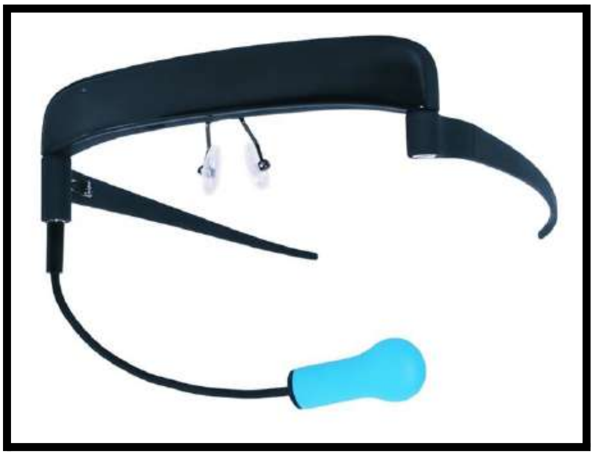
Inputs	**Outputs**
➔ Toggle Switch to turn on the shuttle system ➔ PTM Switch to disable the autonomous route if needed in an emergency ➔ LDRs to assist the system in the road ➔ IR Sensor to avoid oncoming obstacles or uneven surfaces ➔ Microphone to collect voice-assisted data	➔ DC Motors that drive the system ➔ LEDs for the exterior for other drivers when indicating and visibility ➔ LEDs to indicate if the system is on and battery health ➔ Speaker so it can say what directions it can go, how many minutes are left to finish the journey, alerts if the system detects an object close to the pod etc.

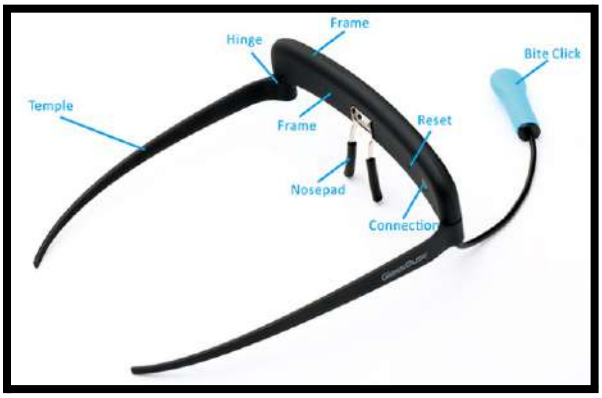
Technological Aids

Technological Aids are defined as specialised computers that help people who can't speak at all, who have what we call a disability.

(Definition from Bethany H: https://prezi.com/u1qxssjaf4kk/technological-aids/)

This technology also helps the person read their emails, listen to their music; watch DVDs etc. Modern technology has vastly improved the accessibility of modern products and services users with disabilities such as allowing them to participate in work areas, basic tasks such as navigating through the internet and home appliances etc. I have researched the area of Technological Aids and how it can assist and vastly improve its accessibility for people that have the lack of abilities to perform it:





1. This is the GlassOuse Assistive Device, aiding people with limited hand function and lack of accessibility on working with computers or smart devices etc. The GlassOuse device uses a bite click mechanism where the user can bite onto the microphone look-alike (seen in headsets) to perform the operation they want to do. Using sensors and cameras, the GlassOuse device can detect what the individual wants to do by moving their head, similar to dragging with a mouse. The computer / smart device receives data back from the GlassOuse device and can transmit that information and perform that function that the individual chose. Developed by the company GlassOuse themselves, the assistive device is compatible with most products and is easy to use. This allows the user to communicate easily and perform tasks, using modern technology to help aid them.

   The GlassOuse Assistive device fits this year's brief since it contains an electro-mechanical element and it can drastically improve the life of a person with a disability. I could design a model with a limit switch or a tactile push button mechanism. I could also design a model where if the user wants to turn on a motor or lights for example,they could use the bite mechanism if they want to turn it on or off.

Sources:
https://www.youtube.com/watch?v=JnRiYeOn2GY
http://www.inclusive.co.uk/glassouse-assistive-device-v1-2
https://interestingengineering.com/glassouse-assistive-device-gives-extra-hands-limited-mobility

Inputs	Outputs
➔ Toggle Switch to turn on the assistive device ➔ Motion Sensors to detect movement ➔ Limit Switch / Push tactile switch to detect if the bite mechanism has been triggered ➔ LDRs to turn on lights if the assistive device is used in low light conditions	➔ LEDs as stationary lights to assist the user in low light conditions, also can be used in way to reduce harmful blue light from screens ➔ LED to indicate if the assistive system is on ➔ LEDs to indicate the battery state ➔ Speaker if a button has been pressed or used to confirm the action

2. This is the Olive Pro, a next-gen hearing aid and a handsfree set, developed to amplify the surrounding environment, while keeping it sustainable and affordable for anyone. Using noise-canceling technology and personal sound amplifying technology (PSAT) to make it much easier for people with hearing difficulties who can't hear easily in everyday conditions since some old hearing aids were unreliable and didn't have hands-free technology. Developed by hearing company Olive Union, it allows the user to charge this on the go and is very lightweight and ergonomic and easy to use. This makes it much easier for people with hearing difficulties to use hearing aids like this so they can hear much more easily.

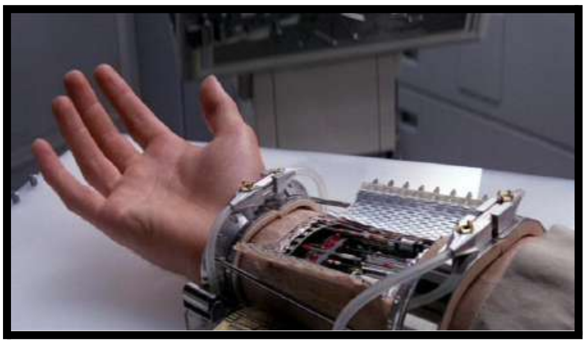
The Olive Pro hearing aid fits this year's brief since it can improve the quality of a person with a disability and it contains an electro-mechanical element transferring from the inputs (microphone) and converting it to a digital signal which is then amplified to increase its strength, making it much easier for the user to hear. I could design a model with small speakers with higher amplified frequencies and lightweight body to make it more ergonomic for people with hearing problems.

Sources:
https://dornob.com/heading-toward-affordable-medical-technology-with-the-olive-next-gen-hearing-aid/
https://www.oliveunion.com/us/?

Inputs	Outputs
➔ Touch Sensor to detect commands such as skipping tracks, increasing volume, voice assistant etc. ➔ LDRs to detect if light areas are low (this can be used for the outline for the hearing aid to add some personalisation) ➔ Push switch to turn on the hearing aids	➔ Powerful Speakers that are rich in sound but also modified amplifying the surrounding environment and transmitting it in digital waves ➔ LED to indicate if the hearing aids are on

Medical Devices / Systems

Medical Devices and Systems contribute a lot to many people's lives with disabilities and provide them with a lot of accessibility nowadays making the quality of their life much better. We see medical devices being used in cinemas and pretty much everywhere, the first thing that comes to my mind when it comes to medical devices in disability is in Star Wars '*Episode III: Revenge of the Sith*' and '*Episode V: The Empire Strikes Back*', when both the main protagonists, Anakin and Luke Skywalker get their hands cut off, but in '*Episode III: Revenge of the Sith*', when Anakin is mostly limbless and nearing death, we see the use of technology into play and the use of mechanical prosthetic limbs come and contribute to Anakin's body, making him to walk again freely and with systems keeping him alive. I have researched into the vast areas of Medical Devices and Systems and have found the following examples:



1. These are prosthetic limbs, a cybernetic and machine that help many people's lives who have lost a limb and need some sort of assistance who need to do their tasks or get back into normality again. We see these mostly in movies, mostly in sci-fi genres such as Star Wars. As technology advances over time, prosthetic limbs are becoming more affordable now using low cost materials and mechanics in order to manufacture them and make them available to everyone. The first picture is a prosthetic hand, largely inspired by 'Deus Ex' and also inspired by the third picture which is Luke's cybernetic and prosthetic hand seen in Episode V: The Empire Strikes Back. This prosthetic and next-gen hand using new tech will be available in 2022 with much more efficient and easier ways to move the hand using the nerve system. In medicine, a prosthesis or prosthetic implant is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or a condition present at birth. Prostheses are intended to restore the normal functions of the missing body part. These prosthetic limbs make it much easier for people with amputations to function better and feel the same as us ordinary humans.

The prosthetic limbs fit this year's brief since it contains an electro-mechanical element and can improve the quality of a person with a disability. I could make a model of a prosthetic hand using a combination of Servo Motors,LEDs to guide it and PTM Switches. I could design a mechanism that uses a combination of gears and chains, similar to a pulley system in what we see in airports today driving the luggage belts around.

Sources:
[Overview: Mechanism and Control of a Prosthetic Arm]
[Sensors Could Make It Easier to Use a Prosthetic Limb]
[Prosthetic arms inspired by 'Deus Ex' are coming next year]
[Why is Luke's cybernetic hand superior to the one Anakin receives?]

Inputs	Outputs
➔ Toggle Switch to turn on the prosthetic limb ➔ PTM Switches to control its direction ➔ LDRs to assist if it goes out of its capability (when the arm/leg is flat and it needs to stop the motor) ➔ IR Sensor if required to avoid obstacles ➔ Limit Switches to assist if it hits an object and requires pressure (Hard Surfaces that the prosthetic system can't do)	➔ Servo Motors to drive the mechanism ➔ Speaker if the system detects something wrong ➔ LEDs to indicate if its on ➔ LEDs to assist if it's in low light conditions

2. This is Project Euphonia, a new programme from Google AI that improves accessibility for disabled people with rare conditions using medical technology combined with modern and self-learning technology used by Google from their virtual assistant. Project Euphonia holds big promise to make voice interfaces work with a wider range of speech. Current voice recognition technology is limited for individuals with speech disorders. People with neurological conditions such as Amyotrophic Lateral Sclerosis, Multiple Sclerosis, and Parkinson's, or developmental disorders such as Autism or Cerebral Palsy cannot rely on products like Google Assistant or Amazon's Alexa. By collecting more voice data from people with impaired speech, however, Project Euphonia will allow for optimization of AI algorithms to improve how computers understand and transcribe impaired speech. The company is also developing technology that detects non-speech sounds and gestures to mimic spoken command responses. This makes it much easier for people with limited abilities to use modern technology such as motion sensors and cameras to determine what they want, making it much easier to understand their expressions and thoughts, without the need of another individual to translate, making it much more efficient for them.

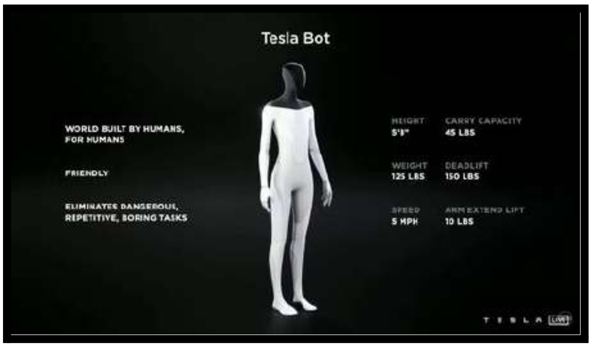
This assistive device can fit this year's brief since it contains an electro-mechanical element and it improves the quality of a person with a disability making it much easier for them to have a voice and be involved like everyone else as a human. I could design a model where cameras and motion sensors can be used to detect the movements from the user and transmitting it to digital waves where it's converted to words, eg. hi or bye etc.

Sources:
New Google AI Projects Improve Accessibility for Disabled Users
LibGuides: Physical and Mobility Disability: Common Assistive Technology
https://www.youtube.com/watch?v=OAdegPmkK-o&t=18s

Inputs	**Outputs**
➔ Toggle Switch to turn on the Euphonia project system ➔ LDRs to assist if it's in low light areas ➔ Cameras to assist the movement detection and where the eyes are facing ➔ Motion sensors to detect movement ➔ PTM Switch to turn off / on / or to confirm the action they want to do	➔ LED to indicate if the system is on ➔ LEDs as symbols so the user can understand ➔ Output Display so user can see the words ➔ Speaker so the user can understand what they are hearing

Independent Living

Independent Living has become an essential factor for many people with disabilities where they cannot function without an individual or an assistant. Modern technology has significantly impacted and improved the lives of people with disabilities and limited function when they are independent and do not have an individual to always guide them. I have researched the area of independent living and how modern technology can assist users with limited mobility and how it can improve their lives and found the following examples:



1. This is the recently announced Tesla Bot, an AI assistant that can assist many individuals who cannot do tasks on their own due to disability. Valued at $35,000, this AI robot is very user friendly, can do multiple tasks that us ordinary people do at home and can assist the users in many different ways. This is very useful for disabled people who live independently and find it difficult to live alone without an assistant. Examples include calling someone,ordering shopping or even doing the lawn or cleaning the house. The assistant is self-learning using quantum mechanics and uses the very same software used in Tesla's car models such as 'Autopilot'.

   This makes it much more efficient and safer for users who need assistance at home when they cannot do it by themselves due to their lack of mobility and function. These can be very helpful for people who are disabled and unable to do tasks that require strength to do so.

This Tesla bot fits this year's brief since it contains an electro-mechanical element and can drastically improve the quality of a person with a disability. I could design a robot that can carry basic objects such as bowls with cereal and deliver it to a location. I could design a mechanism using a combination of DC Motors,LDRs, IR Sensors and develop a track to test its overall capability without losing its function making it reliable and easy to follow.

Sources:
[Musk: The Tesla Bot is coming]
[Tesla Bot Takes Tech Demos to Their Logical Conclusion]

Inputs	Outputs
➔ Toggle Switch to turn on the robot ➔ LDRs to keep it in lane ➔ Cameras to assist the robot ➔ IR Sensor to avoid obstacles ➔ PTM Switch to cancel or to start its function	➔ DC Motors to drive the mechanism and the robot ➔ LED to indicate if it's on ➔ LEDs to indicate the battery's percentage and to provide light in low light conditions ➔ Speaker to assist the user if the robot is near

2. This is Amazon Alexa, a smart voice assistant that can guide people who need assistance instead of doing it physically. The voice assistant market is very competitive, high tech companies such as Google, Apple and Microsoft compete to have the best and most efficient assistant possible with their products such as Google Assistant, Siri and Cortana. Due to this competitive market, these products get better over time, giving a huge advantage for people with disabilities to live independently without any concerns. Using voice-recognition technology, these assistants can help a lot by ordering shopping, turning off the lights, calling people etc. This allows people with disabilities to become more confident with these assistants, helping them to do daily tasks without the need of another individual. Companies such as Google and Amazon are developing products and services with other people with limited ability, allowing them to have more freedom and assistance over living independently.

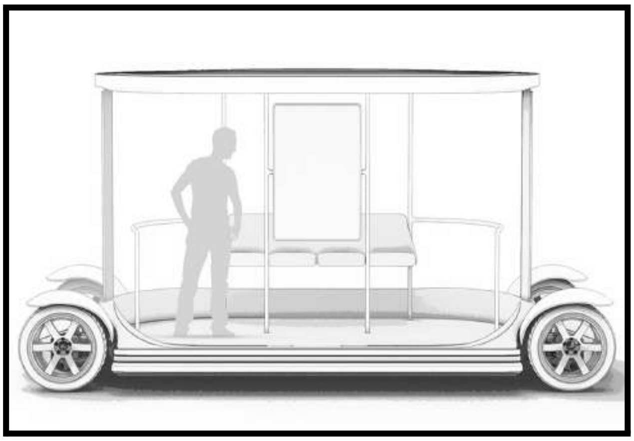
   The voice assistant fits this year's brief since it contains an electro-mechanical element and it can drastically improve the quality of a person with a disability. I could design a model that can respond to the user if it needs something or to talk to them for guidance etc. I could use a mechanism with servo motors,LDRs and microphones so it can detect sound and respond back. I could use an Arduino board to make it easier to programme and respond to basic commands.

Sources:
https://www.wvxu.org/local-news/2020-10-26/smart-home-provides-independence-for-people-living-with-disabilities
https://globalaccessibilitynews.com/2020/09/30/welsh-startup-launches-new-range-of-assistive-tech-products-for-independent-living/
https://assistant.google.com/

Inputs	**Outputs**
➔ Bluetooth Receiver / Wireless ➔ Toggle Switch to turn on the Assistant ➔ LDRs to assist if it's in low light conditions ➔ Microphone to detect voices ➔ Motion sensor to detect movement	➔ Speaker to respond from the assistant ➔ LEDs for personalisation and if its in low light conditions ➔ LED to indicate if the system is on

1.2. Specification of Chosen Parameters

Having carried out the initial analysis of the thematic brief I have decided to develop a project that will be based on the following parameters:



Source : [Yanko Design]

1. I intend on designing a mechanically controlled autonomous bus inspired by the design shown in the pictures above from my research.
1. The electro mechanical element of the project will be the motor mechanism by DC Motors.
2. The project will be controlled by the Arduino Board using the following inputs and outputs:
    a. Inputs: PTB Switches, IR Sensors, Toggle Switches and Motion Sensors.
    b. Outputs: Speakers,DC Motors, LEDs
3. The project will be powered by 9V Battery in a 6 x 1.5V battery format using 1500mAh AAA batteries, providing long lasting range and support.
4. I will use the following main materials:
    ➔ Acrylic
    ➔ PLA Plastic
    ➔ Aluminium / Steel Rods for strong support
    ➔ Other smart materials such as wood and fabric to reduce the impact of hard surfaces, making it more durable and comfortable to go on
    ➔ Metal Bolts and Nuts making it easier to dismantle without damaging the whole structure

2. Project Management

2.1 Analysis of Available Resources




Hand Tools	Software	Materials	Machines	Other Resources
Screwdrivers	2D Design V2	Acrylic Sheet	CNC Machine	Computer Access
Hacksaws	SketchUp 2017	Vinyl	3D Printer	Internet Access
Digital / Vernier Callipers	Genie Programming Editor	Steel / Metal Sheets	Belt Sander	Printer Access
Files	Google Drive	Insulated Cables	Disk Sander	Bench Vice
Sandpaper	Google Docs	Fabrics	Hand Drills	Spray Paint
Cordless Electric hand drills	Microsoft Word	Brass	Pillar Drills	
Set Squares	Visual Studio Code (VSC)	Super Glue	Soldering Iron	
Scribers	Solidworks 2020	Smart Materials	Strip Heater	
Rulers	Arduino Software	PLA Plastic	Vacuum Former	
Wire Strippers / Cutters		Liquid Solvent	Vinyl Cutter	
Solder Sucker				
Long Nose Pliers				

2.2 Analysis of Time Available

The following tables are an analysis of the time available to complete the project.

- ➔ The first table is a calculation of the maximum number of hours available on the project, setting an upper-bound and accurate estimate of the value.
- ➔ The second table is a realistic approach and estimate on the number of hours that I can plan to complete my project as it accounts for the holidays, days absent, theory classes, other subject classes, school closures and has allowed for a realistic approach on the time I have available to plan on the project and the folio itself.

Table A
➔ **Total Weeks : 24**
➔ **School Days : 120**
➔ **Class Days : 72**
➔ **Classes : 96**
➔ **Hours : 80**

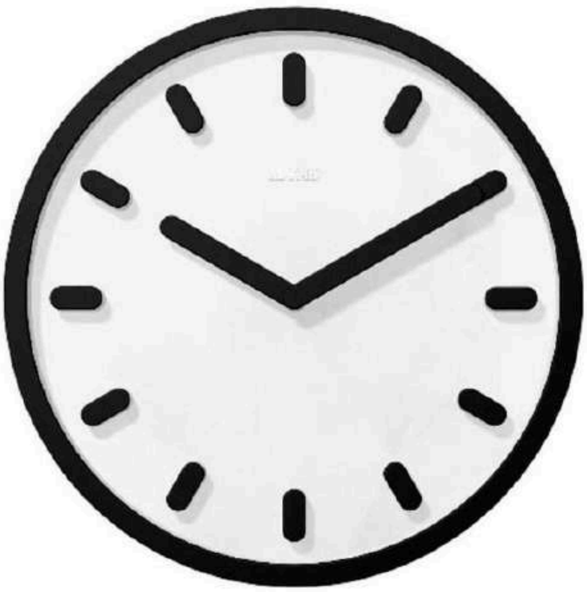
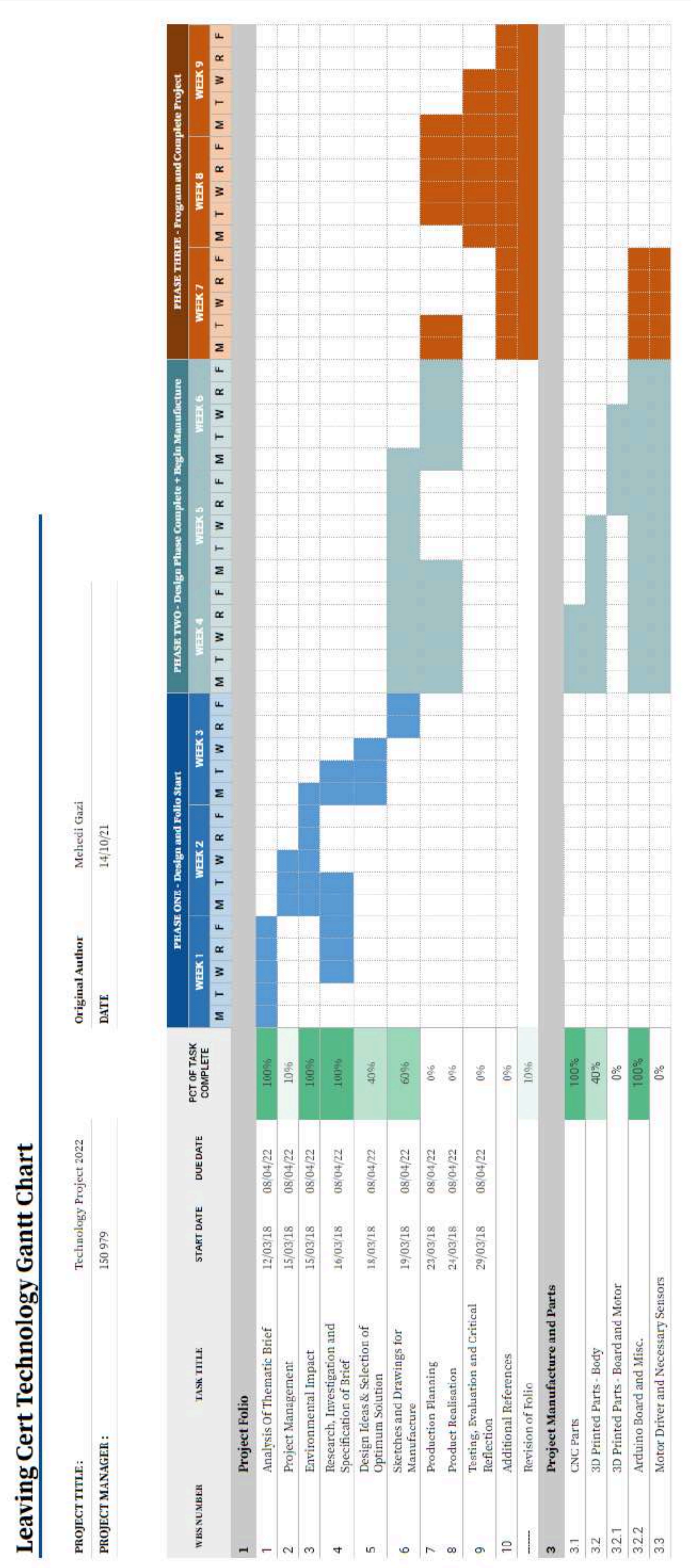


Table B
➔ **Total Weeks : 19**
➔ **School Days : 95**
➔ **Class Days : 57**
➔ **Classes : 76**
➔ **Hours: 63 ⅓**
➔ **Actual Hours :57**

***The actual hours allow for 5 Minutes in each class setting up at the start and cleaning up at the end.**

2.3 Proposed of Timeframe Gantt Chart



2.4 Analysis of Budget Constraints

My proposed budget for this project is €80. I have allocated extra money for electronics due to the complexity and advancements of my project based on the thematic brief. The following table outlines my initial allocation of funds for the various headings.

➔ Materials	➔ Electronics	➔ Other
€ 30	€40	€10

Cost Breakdown		
Acrylic	Arduino Uno R3	Unanticipated Costs
3D Printer Filament	L293D Motor Board Shield	
Aluminium Rod	Gearbox DC Motors	
4mm Plywood	Servo Motors	
Any other materials	Ultrasonic / IR Sensor	
	LEDs	
	Male to Female Jumper Wires	

3. Environmental Impact

3.1 Analysis of Material used in Manufacturing

3.1 (I) Analysis of Raw Materials used in the project

→ Materials	→ Uses
	**Acrylic :** - Variety of thickness, ranging from 3mm to 6mm - Vast Range of Colours - Can be solid color, tinted, transparent or translucent - Relatively inexpensive to manufacture - Sustainable and Recyclable - Supplier : Miko Metals
	**Metal :** - Various Metals Available, ranging from Copper And Aluminum, to Brass and Stainless Steel - Variety of thickness, ranging from 0.5mm to 5mm max - Can be a solid or modified with holes and other modifications (Holes or boundaries for assembly) - Inexpensive to manufacture and mass-production - Supplier : Miko Metals
	**PLA :** - Vast Range of Colours - Can be modified easily - Inexpensive to manufacture for mass production - Made with sustainable materials and recyclable - Suitable for use in 3D Printers - Supplier : SG Education and Sindoh Filament
	**Wood :** - Can be modified and shaped easily - Vast Range of materials (eg. plywood, oak and mahogany) - Ranges from MDF, Hardwood to Softwood - Recyclable and Sustainable - Suitable for hard surfaces or decoration - Supplier :

3.1 (II) - Environmental Impact of the Project Materials

Many modern materials use different methods for mass-production in terms of the global market. This usually requires a large amount of work and energy in order to make the price of a unit competitive and low cost as possible in order to achieve a better product.When selecting materials for the project, there are a number of factors you have to consider before finalizing on what material will be used for the project. In this subsection I have researched the environmental and production elements in order to finalise the impact the materials do to the environment. Here I will examine and analyse the issues and advantages to guide on what materials I am going to use for my project.

➔ Materials	➔ Details
 	**Acrylic Plastic:** - Acrylic, like many plastics, are made from crude oil, an organic resource from the Earth used for many materials and fuel all around the world. The production of acrylic plastic from crude oil accounts for 8-10% of the oil's supply per year which accounts for over 60 billion Joules (J) which is a substantial amount going to waste when it can be used for other useful sectors in the global industry. - The extraction of crude oil can be costly and damaging to the environment, accounting for marine wildlife damages and huge damage towards the ocean landscape and its ecosystem. - Acrylic plastic's life cycle is short and also very fragile since it requires proper and sustainable recyclable methods but with the modern technology available, it's not possible at the moment.
	**PLA Plastic:** - PLA Plastics are quite the opposite compared to normal plastics and acrylic, since they consist of using renewable resources such as polylactic acid, sourced from plant starch. - PLA Plastic has skyrocketed in terms of demand due to the low amount of energy needed to produce PLA plastic and using modern technology making it more sustainable and environmentally-friendly using less waste that is gone back to the environment.

	- The PLA plastic is created via modern techniques using melting and compression of the acid with suitable and eco-friendly substances. - PLA Plastic can be easily recyclable and converted into a range of colours and plastics using as little waste as possible.
 	**Metals :** - Metals are made from a range of underground minerals and rocks ranging from stainless steel and aluminum to more exotic and stronger materials such as titanium - The production of metals and associated materials requires a huge amount of energy (211 GJ roughly per tonne depending on what metal) - Metals are much different compared to plastics, they have better recycling methods that are eco-friendly and can be melted easily into other shapes and other form factors without any waste.
 	**Wood :** - Wood is an organic material, extracted from trees in the forests and can provide a vast range of woods from common oak to more exotic types used for furniture such as mahogany. - Wood is mostly eco-friendly and a non-finite resource, however this depends on the demand and sustainability by industries since deforestation and urban sprawl can slow the growth of trees. - Wood can be easily recyclable. With modern technology the waste of wood from factories can be produced and combined to a wood platform known as MDF. - Wood's energy usage is relatively low (19.2 GJ per tonne) compared to high energy based materials such as acrylic and metal with over 100+ GJ per tonne to manufacture.

3.1 (III) Possible manufacturing processes for chosen materials

There are many methods I can use to manufacture the project with the materials that are available and I have chosen from the following subsections. In this subsection I will examine and analyse the manufacturing processes available for my project.

➔ Material	➔ Suitable Processes
	**Acrylic :** - Bending: Strip Heater / Vacuum Former - Shaping : Belt Sander - Cutting : CNC , Band Saw, Scroll Saw , Hand Saw - Drilling : Pillar Drill / Cordless Drill - Finishing : Peek Polish

	**PLA Plastic :**
	- Best suited to work with a 3D Printer
	- Afterwards once the 3D Model is complete the following processes are available to later modify.
	    - Sanding
	    - Drilling

	**Metals :** - Best suited to work with machines / heavy duty tools - Shaping - Files and Hard Surface Sanding - Cutting - CNC - Drilling - Heavy-Duty Cordless Drill / Pillar Drill

3.2 Consideration of Energy Requirements

3.2 (I) Energy Requirements involved in the production and transportation of materials

The materials I finalised and selected requires a large amount of energy involved in order to manufacture it, through mass-industry based processes. In this subsection I will evaluate and examine the energy required and consumed in order to create these materials and transport them from the Earth to the Technology classroom.

➔ Materials	➔ Energy used in production	➔ CO^2 emissions of transport
Acrylic Plastic 	- 62 to 108 billion Joules required to manufacture plastic [Converted from Crude Oil to Plastic]	- Approx. 3,400 KG per tonne of acrylic.
Metals 	- 211 Giga Joules (J) per tonne	- Approx. 100-101 KG of CO^2 per tonne of metal.
PLA Plastic 	- 3.6 Mega Joules (J) per KG	- Approx. 2,740 KG of CO^2 per tonne of PLA Plastic.

3.2 (II) : Energy Requirements of the completed project

- The energy requirements of my project, Campus Shuttle, has a sleek and modern design, using a 9V (6 x 1.5V AAA) rechargeable lithium-ion battery to power the project.
- The reason why I opted with rechargeable lithium-ion batteries is because it leaves significantly less carbon footprint than alkaline or one use batteries.
- Similarly to project materials, in order to contribute less carbon footprint towards the environment, they must be reused and recycled in a responsible manner leaving little to no waste left behind.
- In the project, I plan to use the rechargeable battery numerous times and also plan to keep a backup battery in case one runs out of battery.

3.2 (III) : Minimising Energy Requirements through Reuse and Recycling

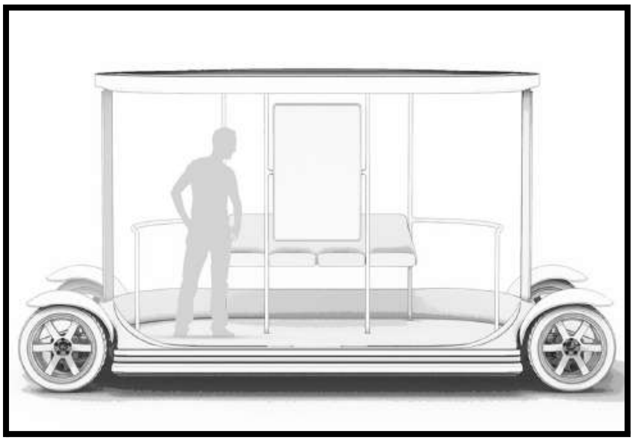
In order to reduce producing waste materials throughout project manufacturing, I adopted the following processes needed in order to reduce carbon footprint and waste within the technology classroom.

➔ Processes	➔ Description
Recycling 	- Recycling waste materials from manufacturing such as CNC and the excess waste from the 3D Printer and Drills etc. - Recycling any circuit elements that are not needed - Recycling any excess solder or excess cables
Use of reusable resources 	- Rechargeable 9V (6 x 1.5V AAA) Battery

4. Research, Investigation and Specification of Brief

4.1. Analysis of Existing Solutions

As described in section 1.2 I intend on designing the Campus Shuttle. The Campus Shuttle can be voice-assistant controlled and used in many different ways that can assist the user. The Campus Shuttle will use a combination of LDRs,IR sensors and microphones in order to navigate and process basic tasks such as turning on lights,moving forward etc.
It was inspired by the autonomous vehicle shown in the pictures below from my research.

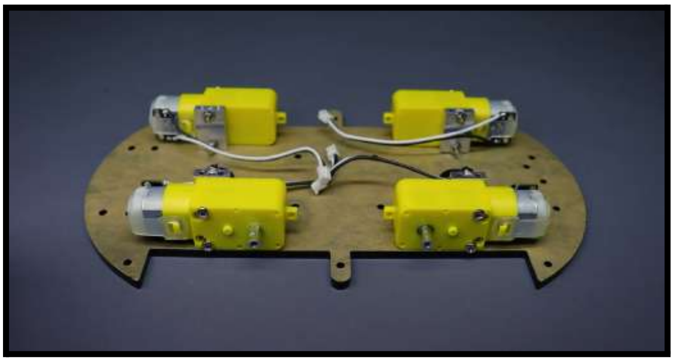


Source : Yanko Design

In this section I will be carrying out additional in depth research into:

- ➔ **Existing Similar Designs**
- ➔ **Suitable Electro-mechanical elements**
- ➔ **Suitable Switches and Sensors**
- ➔ **Suitable environmentally friendly and low cost materials**
- ➔ **Other electronic elements**

Existing Similar Designs



➔ This is a design for a 4-Drive DC gearbox mechanism powering the vehicle. The DC gearbox mechanism allows higher transmission efficiency and it provides no slip or creep during the power transmission to ensure perfect velocity ratio
Pros - Highly Efficient, uses more power compared to belts, high transmission efficiency and easy to repair.
Cons - Requires constant lubrication and and same amount of voltage on all motors,relatively slow compared to 9V DC Motors.
Source: DIY Builder YouTube

➔ This is a design for the retractable accessibility platform, making it accessible for mobile and wheelchair users. The retractable accessibility platform allows better accessibility and maintenance in terms of the mechanism and other factors.

Source: Barton Motion Mechanism

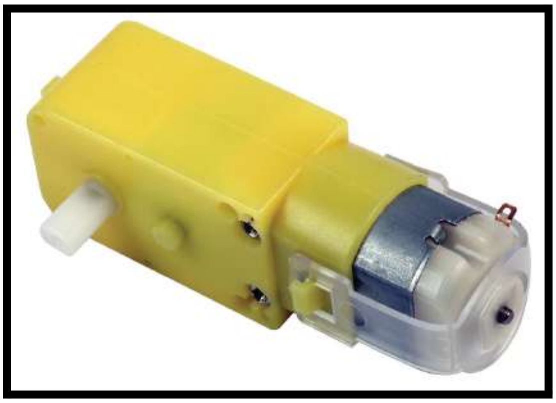
Pros - Easy to maintain, simple design and strong structure
Cons - Requires constant lubrication for the gears and motors, limited weight in terms of load,not even weight ratio.

➔ This is the SAGA Syncro Duo, a mechanism that can open sliding doors simultaneously. The mechanism consists with a combination of gears and motors the slide at the same time making it much easier to to maintain and install. The SAGA Syncro Duo allows a minimalist design built into the glass casing for easier access for passengers and people with limited mobility, instead of using a manual door with some sort of force.

Source: SAGA Syncro Duo

Pros - Minimalistic Design, Easy to disassemble, Advanced sensors, lightweight design
Cons - Cost of Manufacture, Cramped Space, Not an even weight distribution ratio

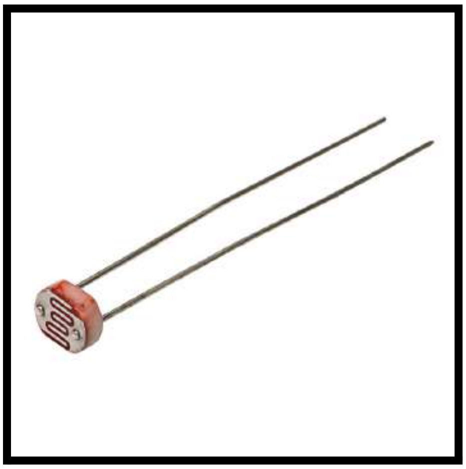
Suitable Electro-mechanical elements



- ➔ This is a DC Motor Gearbox, the DC Motor is a common motor and can be used for many things, for example running a gear-based mechanism,driving wheels etc. The DC Motor's speed and rotation can be controlled using the GENIE 18 Motor Board or using an Arduino Board. With the GENIE Software, I can use easy instructions to control the speed and rotation, however with Arduino Software, I can control it freely since it's based on the C programming language. I can use the DC Motor Gearbox to power the rear wheels in my project.
  Source: DC Motor Gearbox - CPCIreland

- ➔ This is a Tower Pro SG90 Servo Motor. The servo motors are used for many things, it can be used to rotate an object to a specific angle etc. The Servo Motor can be controlled using the GENIE 18 Motor Board or using an Arduino Board. With the GENIE Software, I can use easy instructions to control the rotation and speed, however with Arduino Software, I can control it freely. I can use the Servo Motor to rotate the IR and Ultrasonic Sensor at a specific angle.
  Source: Rapid SG90 Servo Motor (TowerPro)

Suitable switches and sensors



➔ This is an LDR, otherwise known as a light dependent resistor. This is a variable resistor, where the LDRs value by light intensity will fluctuate, optimal for detecting colors,low light conditions etc. I can use this on the smart recliner to detect oncoming obstacles and if there are low light conditions to turn on the LEDs.
Source: [Rapid TruOpto LDR Sensor]

➔ This is an IR (Infrared) Sensor. Infrared Sensors use infrared light to calculate the distance from a set point. Infrared Sensor's values fluctuate depending on the distance from an object or an obstacle blocking its way. I can use this on the autonomous vehicle to detect obstacles that are blocking the shuttle's way if it's manually or autonomously controlled.
Source: [Rapid IR Sensor]

➔ This is an SPST Toggle Switch. It's used to turn on or off the system / board. I can use the toggle switch in my system to turn the board on / off.
Source: [Rapid SPST Switch]

➔ This is a PTM Switch (Push to Make Switch). It is commonly used in everyday applications and in consoles where you can hold the switch while pressing down. Examples include controller buttons seen in consoles etc. I can use this to manually control both motors and for emergency purposes also if they want to reset back to the normal position.
Source: [Rapid PTM Switch RVFM]

Other electronic elements

➔ This is a LED (Light Emitting Diode)
LEDs light up when electricity passes through them. LEDs are very common nowadays, since they are long lasting and far more power efficient than old fashion incandescent lights that use much more power. I can use the LEDs in multiple ways in the Campus Shuttle, such as adding a stationary lamp and adding to assist the sensors in low light conditions
Source: [Rapid LEDs Red Kingsbright]

➔ This is a microphone, used for collecting voice waves and used for the systems to process them. These are very common, used in many systems that we use nowadays such as smartphones, laptops etc. I can use the microphone on my Campus Shuttle to collect voices from the user and process it to do actions that the user commands, for example turning on the lights, moving the mechanism, questions etc.
Source: [Farnell Minatare Arduino Microphone 42dB]

➔ This is a speaker, used for transmitting voices and audio out. Speakers can be seen everywhere nowadays from smartphones all the way to intercoms etc. I can use the speaker to transmit the responses from the system back to the user, after it receives responses using voice commands etc. This can also be used if the system detects an object too close to the sensors, alerting the user that there are objects nearby.
Source: [Visaton Speaker RapidOnline 8 Ohm]

4.2 Further Research

4.2 (I) PIC Microcontrollers

Source:

- Technology for Leaving Cert; Gráinne Enright
- http://www.technologystudent.com/

PIC microcontrollers (Programmable Interface Controllers) are electronic circuits that can be programmed to carry out a wide range of tasks.

PIC Microcontroller Components

- Inputs and Outputs
- Random Access Memory (RAM)
- Read-Only Memory (ROM)
- A Central Processing Unit (CPU)

In Applied Control the PIC chip supplies the 'Process' in the system:

Applications of PIC Microcontrollers

They are extensively used in households today. Examples of such appliances include:

- Microwaves
- Washing machines and Dishwashers
- Television remote
- Video Game Consoles (Eg. Xbox Series X and Playstation 5)
- Personal Computers (Eg. Desktops and Laptops)
- Display units (Eg. TVs and external displays)

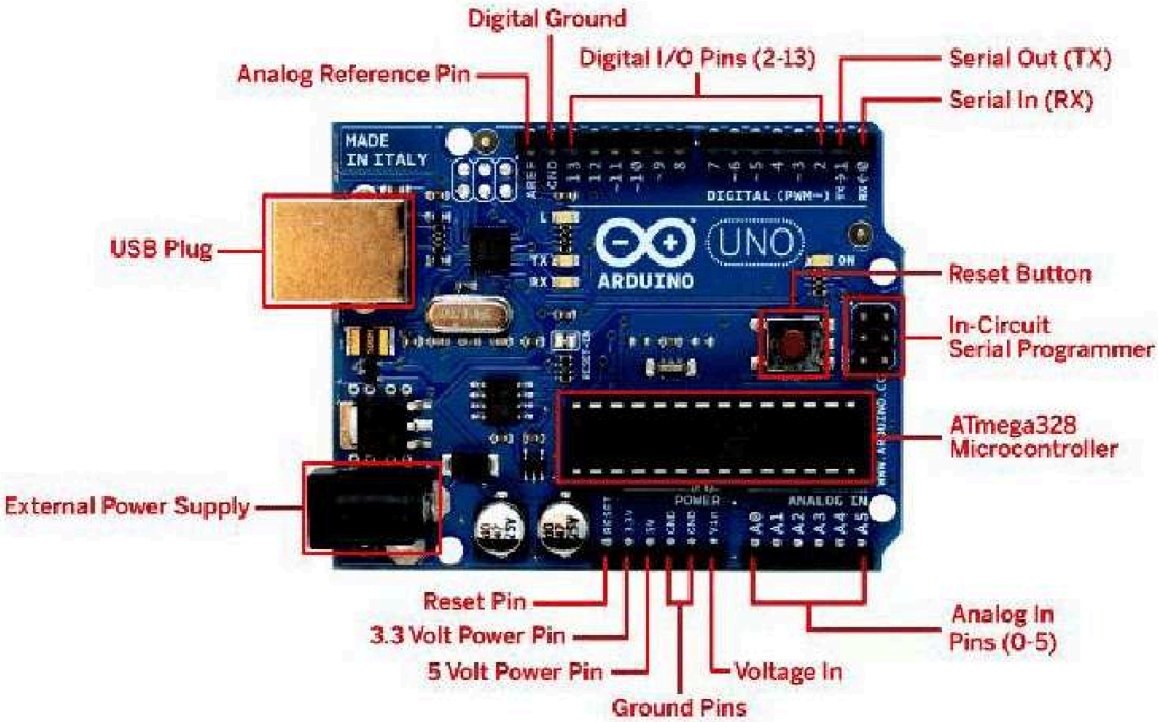
Advantages of PIC Microcontrollers

- Increased reliability in long term usage and extreme tasks
- They can be reprogrammed easily many thousands of times
- Basic and complex programmes can be made using PIC microcontrollers and software that is accessible to use.
- They allow greater flexibility and adaptability in terms of project design and manufacture.

Arduino Uno Board

I will be using an Arduino Uno Board in my project. The advantages to using this board include:

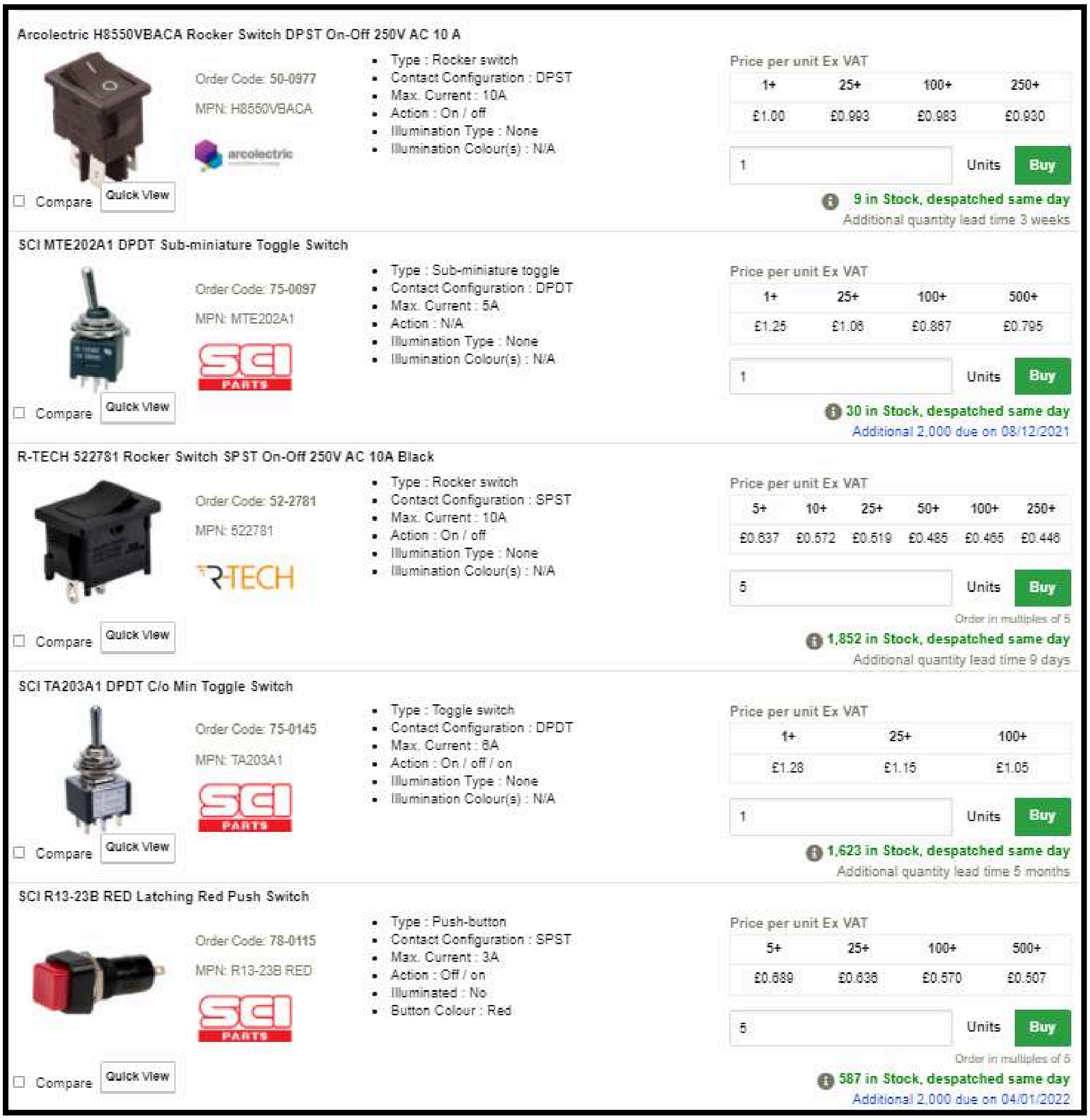
- Vast range of possible inputs - There are 6 possible analogue and digital inputs
- Fourteen possible outputs - including medium power outputs to enable two motors to be used
- A motor driver chip to allow forward/reverse motor control
- An on-board reset switch
- It also includes a download socket to allow the chip to communicate with a computer
- Includes various pins that allow for expansion (for example - adding more motors since the board has a voltage limit of 5V.)



4.2 (b)

(Inputs)		Outputs
Digital	**Analogue**	
Toggle Switch	Thermistor	LEDs
PTB Switch	Moisture Sensor	Motors/Servo
	LDR	Buzzers
	Distance Sensor / Ultrasonic Sensor	Speakers

Numerous switch inputs are available at www.rapidonline.com as shown below:



Numerous motors are also available at www.rapidonline.com :

Rapid Worm Drive Gearbox with Motor

Order Code: 37-0310

MPN: 37-0310

Rapid

- Nominal Voltage : 3 to 6V
- Max Torque : 1.18 to 2.16Ncm
- Speed (No Load) : 9.7rpm
- Speed (Max Torque) : 17.1rpm
- Current (No Load) : N/A
- Current (Max Torque) : N/A

Price per unit Ex VAT

1+	10+	50+
£3.48	£3.00	£2.80

1 Units Buy

Compare Quick View

306 in Stock, despatched same day

Additional 4,000 due on 14/02/2022

MFA 918D30112/1 Gearbox and Motor 30:1 4mm Shaft 12-24V

Order Code: 37-1228

MPN: 918D30112/1

MFA

- Nominal Voltage : 12 to 24V
- Max Torque : 0.24Ncm
- Speed (No Load) : 238rpm
- Speed (Max Torque) : 543rpm
- Current (No Load) : 0.1mA
- Current (Max Torque) : 0.347mA

Price per unit Ex VAT

1+	5+	10+
£9.81	£8.90	£8.75

1 Units Buy

Compare Quick View

38 in Stock, despatched same day

Additional quantity lead time 14 days

MFA 951D101 Gearbox and Motor 10:1 3mm Shaft 1.5 to 3.0V

Order Code: 37-1137

MPN: 951D101

MFA

- Nominal Voltage : 1.5 to 3V
- Max Torque : 0.04Ncm
- Speed (No Load) : 685rpm
- Speed (Max Torque) : 1450rpm
- Current (No Load) : 100mA
- Current (Max Torque) : 320mA

Price per unit Ex VAT

1+	5+	10+
£6.06	£5.63	£5.49

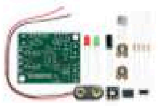
1 Units Buy

Compare Quick View

Available to back Order

Standard factory lead time 14 days

RK Education 555 timer Astable Project - with Drive Circuit



Order Code: 70-6018

MPN: 70-6018

RK Education

- Type : Astable project
- Power : N/A
- Frequency : N/A
- Range : N/A
- Soldering : Yes

Price per unit Ex VAT

1+
£3.28

1 Units Buy

Compare Quick View

38 in Stock, despatched same day

Additional quantity lead time 4 months

Pimoroni COM0802 Micro Metal Gearmotor 1006:1 Extended Back Shaft

Order Code: 75-0640

MPN: COM0802

PIMORONI

- Nominal Voltage : 6V
- Type : DC gearmotor

Price per unit Ex VAT

1+
£4.63

1 Units Buy

Rapid PCB Mounting Microphone Insert

Order Code: 35-0192

MPN: ECM60PB

Rapid

- Frequency Response : 50Hz to 12kHz
- Impedance : 300R
- Height : 7mm
- Sensitivity : -60dB

Price per unit Ex VAT

2+	26+	100+
£0.984	£0.692	£0.557

2 Units Buy

Order in multiples of 2

Compare Quick View

7,862 in Stock, despatched same day

Additional quantity lead time 5 months

KEPO KPCM-94H65L-40DB-1689 Microphone Capsule with Flying Leads

Order Code: 52-1023

MPN: KPCM-94H65L-40DB-1689

Kepo

- Type : Microphone capsule
- Frequency Response : 100Hz to 10kHz
- Impedance : 2200Ω
- Sensitivity : –40dB

Price per unit Ex VAT

5+	25+
£1.02	£0.896

5 Units Buy

Order in multiples of 5

Compare Quick View

144 available to back Order

Standard factory lead time 9 days

Kemo B085 Parabolic Microphone Kit

Order Code: 13-0480

MPN: B085

Kemo

- Type : Microphone kit
- Power : 9V
- Range : 2m
- Soldering : Yes

Price per unit Ex VAT

1+
£8.22

1 Units Buy

Compare Quick View

57 available to back Order

Standard factory lead time 9 days

4.3. Statement Outlining Final Brief and Related Specifications

Having carried out extensive research in sections 1.1, 4.1 and 4.2 I have developed the following list of specifications for my project design:

1. I am going to design an autonomous vehicle known as 'Campus Shuttle' that assists users to use public transport and rely less on additional human assistance. This complies with the thematic brief since it has an electro-mechanical element and can improve the life of a user with limited ability.
2. I will base my designs on the existing design(s) shown below that I found in my research:

Source: [Yanko Design]

3. The main materials used for the structure of my project will be:
    - PLA Plastic in Black used for 3D Printing
    - Transparent Acrylic used for the glass casing
4. I will be using the following inputs and outputs with the Arduino Uno Board:
    - Inputs: Standard LDR / other sensors and microswitch with (Rapid Code: 562023)
    - Outputs: Servo motor (Rapid Code 499395) and standard LEDs and Gearbox DC Motors
5. The electro-mechanical element of my design will be a mechanism based on a combination of DC Motors with a servo motor controlling the door.
6. I will include the following safety considerations:
    - No sharp edges
    - No dangerous moving parts
    - No toxic material
    - No electrical hazard
7. I intend to complete the manufacture of my project by Friday 18th March, allowing 3 weeks for testing and commissioning.
8. The budget for this project will be €80 maximum.

5. Design Ideas & Selection of Optimum Solution

In this section I will outline the progression of my proposed design idea outlined in Section 4.3 ‘Statement Outlining Final Brief and Related Specifications’ from its initial concept to the final optimum design.

This section contains subsections as follows:

- ➔ **5.1 Annotated Sketches and Drawings of Possible Solutions**

This section includes three annotated freehand sketches of my design progression using numerous methods of visualisation and simulation. The analysis and annotations are explained on an accompanying page.

- ➔ **5.2 Identification of Optimum Solution**

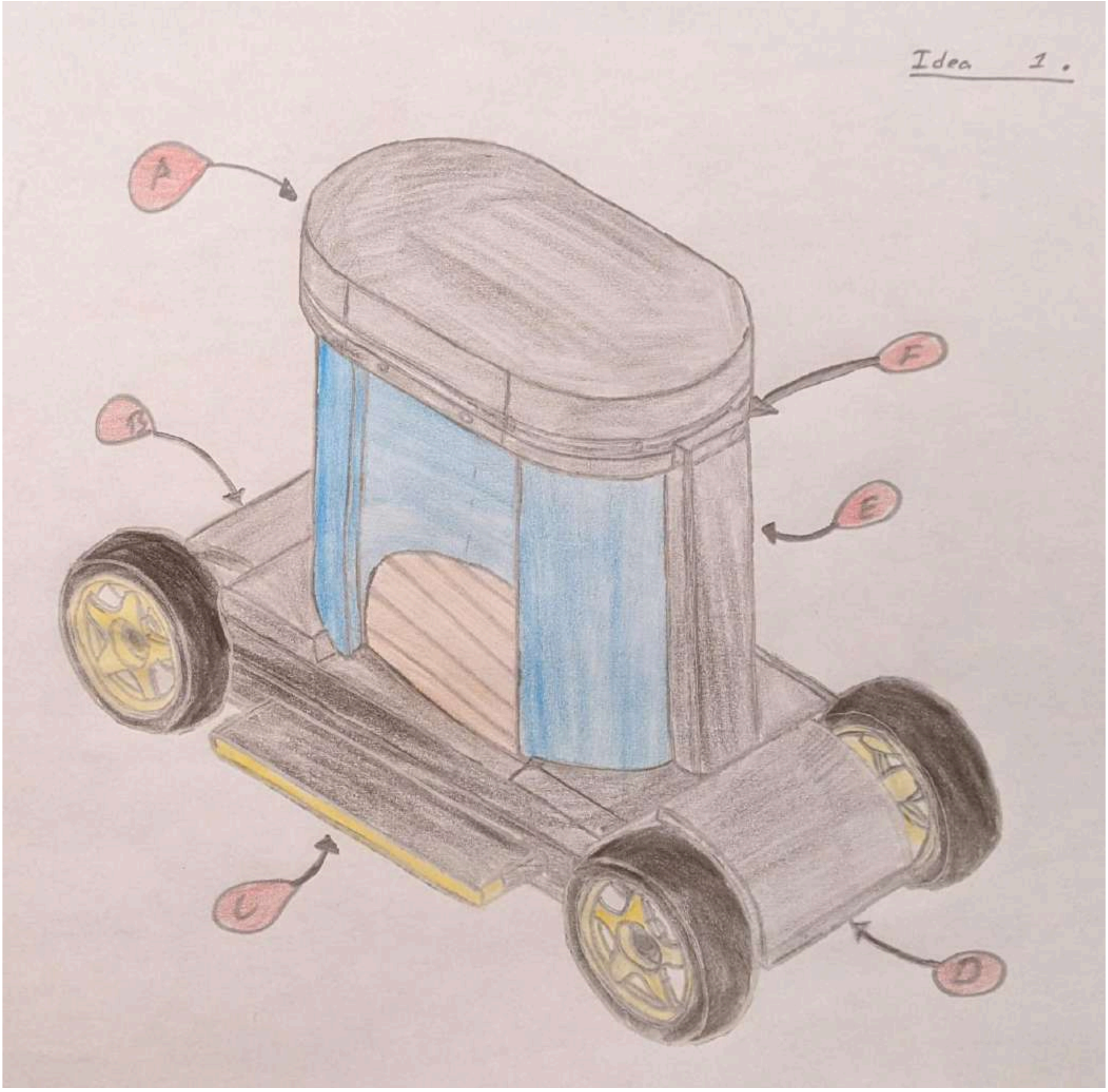
This section includes multiple annotated screenshots of optimum design drawn using the 3D CAD program SolidWorks 2020 (Student Edition) including screenshots of the interior, Section Views, mechanical sections and control components.

- ➔ **5.3 Justification of Optimum Solution**

This section contains a justification and statement of why I feel this is optimum design as well as its advantages and disadvantages in the overall design and concept.

5.1. Annotated Sketches and Drawings of Possible Solutions

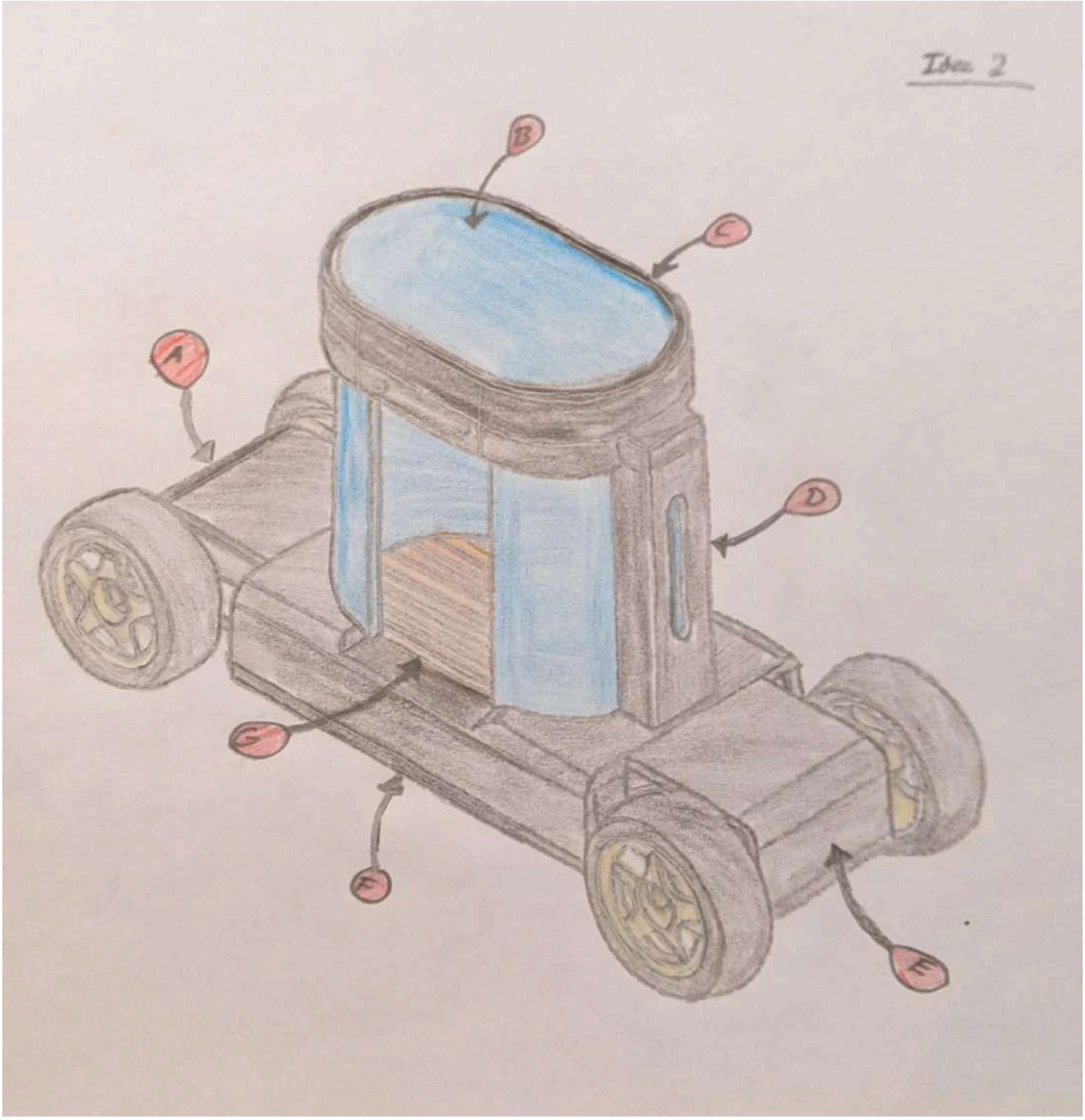
(Design Concept and Idea 1) (Freehand Sketch)



Idea 1 Annotation Key	
A	This is the housing for the Arduino Uno and the L293D 4-Channel Driver Motor Shield. Inside the cover the Arduino and the Motor Shield will be very accessible to control from, allowing easier modifications and accessibility on the whole system.
B	The front side contains the LDR and IR Sensor in the curved housing. The sensors allow for easier control and allow the wheels to be stable when turned on. When in operation, the sensors allow movement and avoid obstacles when turned on. In a scenario this can be used when pedestrians or objects are in the way when the system is running.
C	This is the retractable platform that I plan to make for my project. The retractable platform allows people with limited ability to get in the vehicle without manual interference, controlled fully autonomous when turned on and allows easy access for maintenance since it will be controlled by guide rails used on CNC machines with a pinion and rack mechanism .
D	This is the back side of the vehicle and the battery housing will be situated on top of the motor housing. The curved design allows a more simplified design and creates less collision with the motors. The motors in the front and back consists of a 4 motor-drive design, which allows motors to independently work and avoid obstacles while making the user comfortable when the system is on.
E	This is the glass housing that will be made using a vacuum former and making a mould based off from CNC pieces that are supported by 5mm acrylic waste pieces and using liquid solvent to further strengthen the mould when under intense heat by the acrylic that will be used in my project. The glass structure allows further stability for the board to be housed in and allows further creativity and design in the overall idea while using reusable materials to reduce the carbon footprint used for producing the overall project.
F	This is the wire chamber that connects the control pieces at the bottom to the main board at the top. The hidden chamber at the back allows easy access and can be easily disassembled to fix any cables that may cause interference when the project is turned on.

Idea 1 (Advantages):	**Idea 1 (Disadvantages):**
➔ The design is aesthetically pleasing and is similar to the reference image as shown in the previous sections. ➔ Numerous structure supports were added to avoid collapse and further enhance stability in the overall project. ➔ The board and the control components were independently placed so it can easily be modified. ➔ The 4 Motor-Drive system allows easier rotation and allows the motors to work independently when it is turned on.	➔ The curved sides at the front and back may not be suitable for the motors,sensor and the battery which may further cause problems in the project. ➔ The retractable platform may cause issues for the cabling and can be hard to assemble in such a compact space when space and accessibility matters in the overall project.

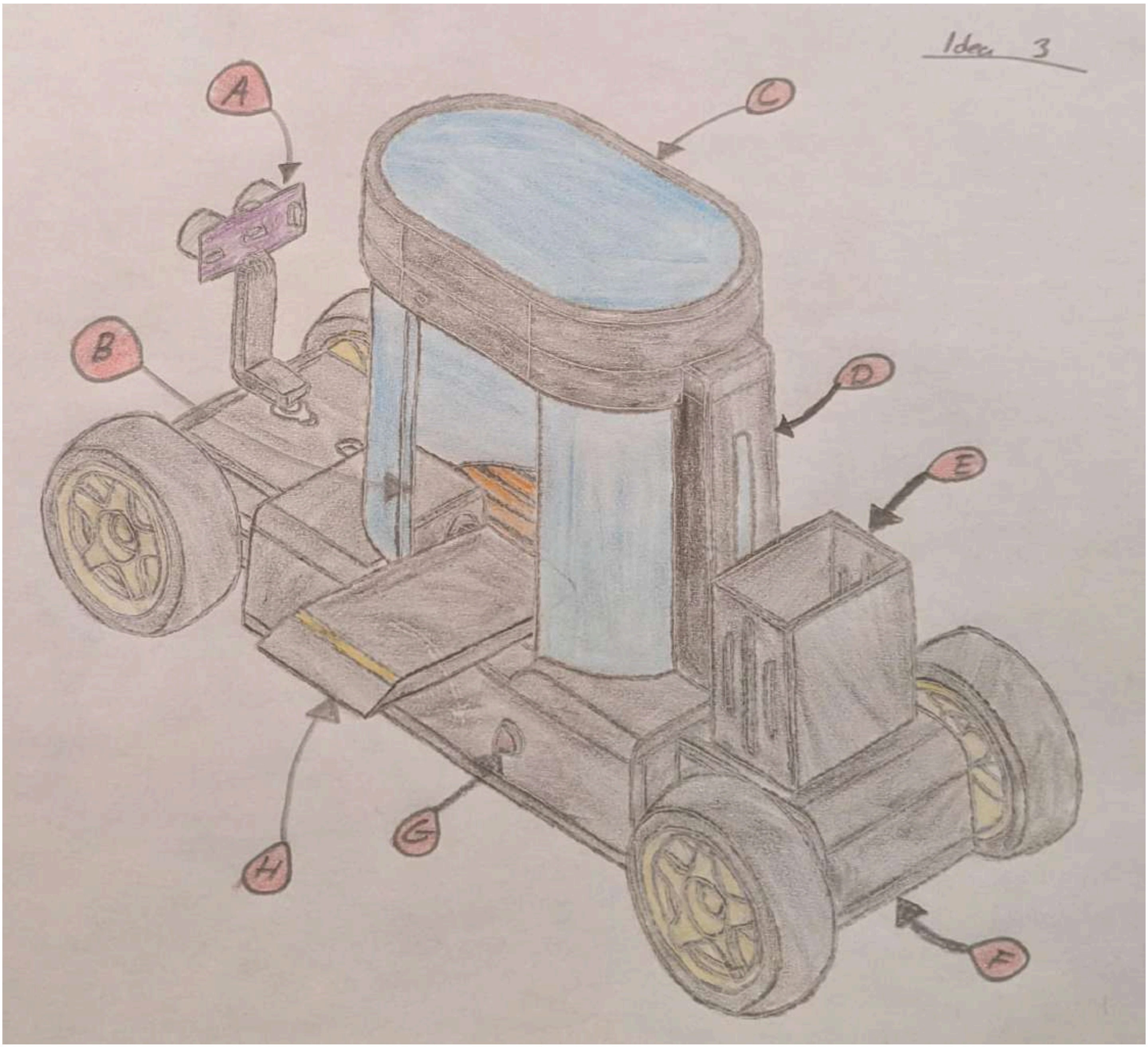
(Design and Concept Idea 2) (Freehand Sketch)



Idea 2 Annotation Key	
A	The frontside was redesigned with a much sleeker housing allowing easier accessibility and modifications that were needed to make the project more efficient and easier for the motors and wheels to function. Both sides have a 3mm acrylic casing to secure the wheels and motors, further providing stability when in operation.
B	The top was redesigned with a 5mm glass top and further supports to the board section so it can be easily removed when some modifications were needed when in use.
C	The board chamber was redesigned to include mounting holes to secure the board in place and areas where it can be easy to add additional components.
D	The wire chamber was redesigned with a 3mm casing to allow wires to be seamlessly configured and an additional glass section was added to see the wires in use and give an appealing design at the back.
E	The backside was redesigned similar to the frontside allowing a much more stable housing for the battery to be situated in, allowing easier modifications and avoiding further complications in place.
F	The retractable mechanism was removed for Idea 2 to work on the overall design with significant improvements to make it easier to manufacture while making the project similar to the reference images and that I based it from Section 1 and 4. A redesigned base was added at the bottom to allow components to cool down seamlessly when in use.
G	A customised wood board was added in place to give the project some eco-friendly features, using a combination of PLA Plastic, Acrylic and Plywood.

Idea 2 (Advantages):	Idea 2 (Disadvantages):
➔ The design is much more aesthetically pleasing when most components are in line with the main areas and is much more similar to the concept and the reference image as described in the previous sections. ➔ The front and back side have numerous advantages in terms of placement for control components to be housed in. ➔ The addition of eco-friendly materials further reduces the cost and carbon footprint on the overall project. ➔ The project is based off 60% 3D Printing, 30% CNC and 10% Plywood allowing the materials to be reused in future projects when disassembled. ➔ The 4 Motor-Drive system allows easier rotation and allows the motors to work independently when it is turned on.	➔ The IR and LDR Sensor may not be compatible for the project due to the major modifications and reworks on the project, which may lead to exploring better and advanced sensors to be used in the project. ➔ The absence of a retractable platform may weaken my solution allowing disabled people and can weaken the functionality of my project and the absence of battery housing may need to be reworked in Idea 3.

(Idea 3) (Sketch)

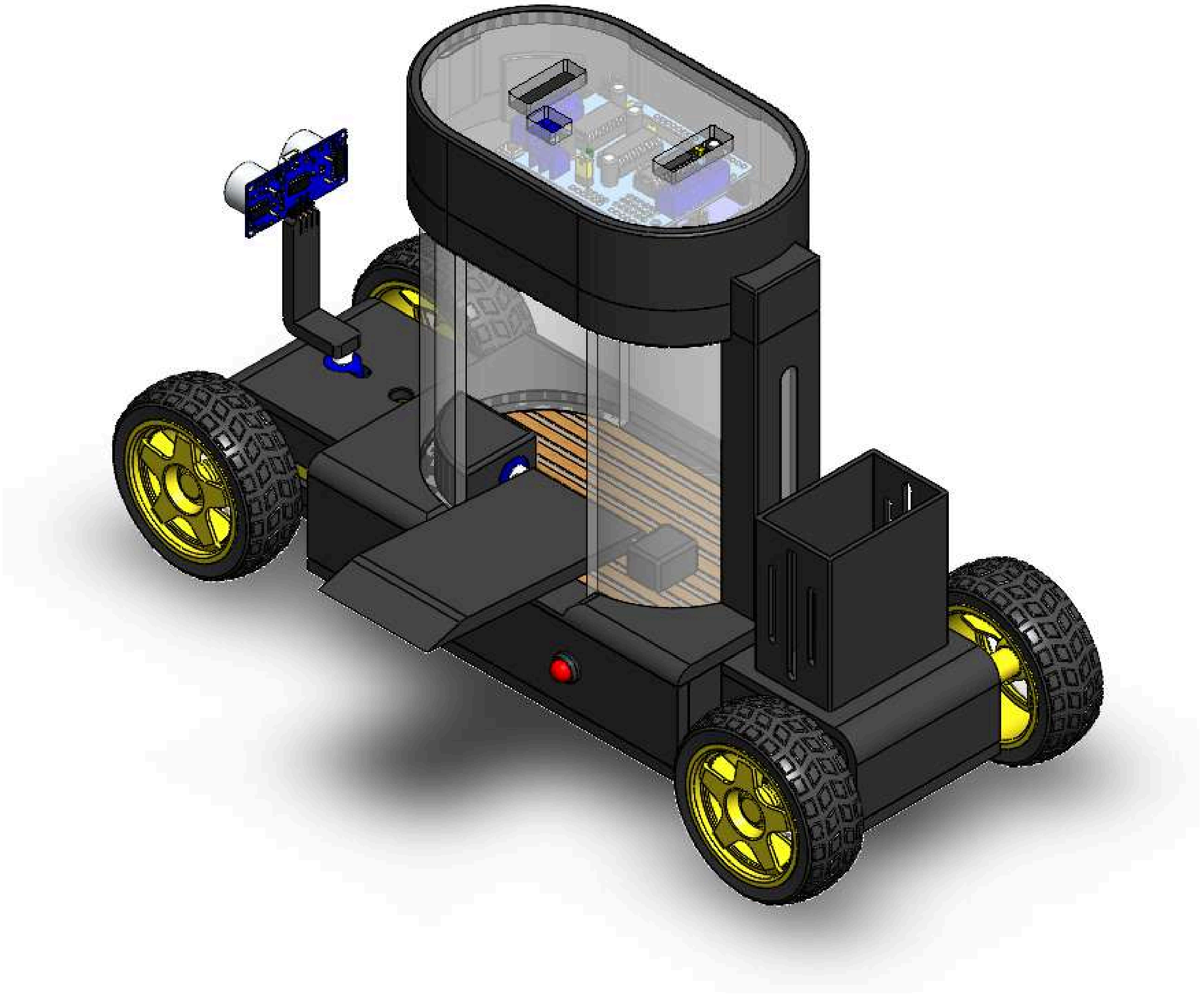


Idea 3 Annotation Key	
A	An Ultrasonic Sensor (HC-04) was added to replace the IR Sensor and LDR sensors previously mentioned in Idea 2. The HC-04 can easily be modified and programmed compared to LDRs and IR Sensors since it relies on radio waves instead of light values, which increases the reliability and makes the project much easier to work around with.
B	Retractable platform housing was added to allow people with limited ability to get on the vehicle easily. The mechanism consists of a servo motor locked on with an axle connected to a piece at the other side which stabilises the platform.
C	The board chamber was modified due to the extended height so the cables can easily be managed. This allows for better cable management and easier access to each individual cable connected to the control components underneath.
D	The wires inside the wires chamber were replaced using grey embedded wires to allow more space for other wires from other control components.
E	A battery housing was added with a sleek and simple design at the back so the battery can easily be disassembled at the back and replaced when it's empty rather than charging with a cable. Gaps were added at the side to allow better airflow when the battery is in use.
F	The retractable mechanism was removed for Idea 2 to work on the overall design with significant improvements to make it easier to manufacture while making the project similar to the reference images and that I based it from Section 1 and 4. A redesigned base was added at the bottom to allow components to cool down seamlessly when in use.
G	LEDs added so they can turn on when the gearbox motors are in use. This provides the system some functionality and allows pedestrians to know in what direction the vehicle is moving in.
H	Retractable Platform with a simple axle mechanism that allows it to rotate up and down without any collision. The rotation allows the platform to be a door and a gate for the wheelchair users at the same time, allowing passengers to get on and act as a door when the platform is rotated upwards in a 90 degree angle.

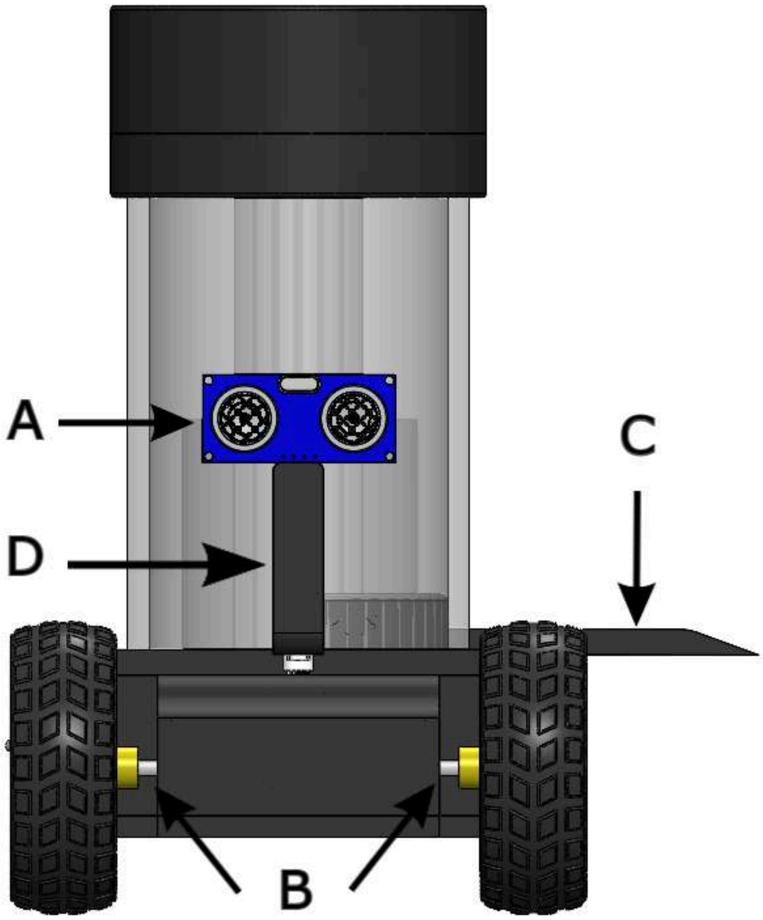
Idea 3 (Advantages):

- ➔ The design is much more simple and aesthetically pleasing to look at due to its advanced features and functionality.
- ➔ The LEDs and the HC-04 Sensor give some personality to the vehicle when turned on and provide awareness for pedestrians nearby.
- ➔ Idea 3 now has various structural supports with different materials and areas where all the space is used to stabilise the vehicle and allow better rotation and movement when an obstacle is nearby
- ➔ The project is much easier to work around with due to extra space added to give some extra workspace for cables and other components.

5.2 Identification of Optimum Solution

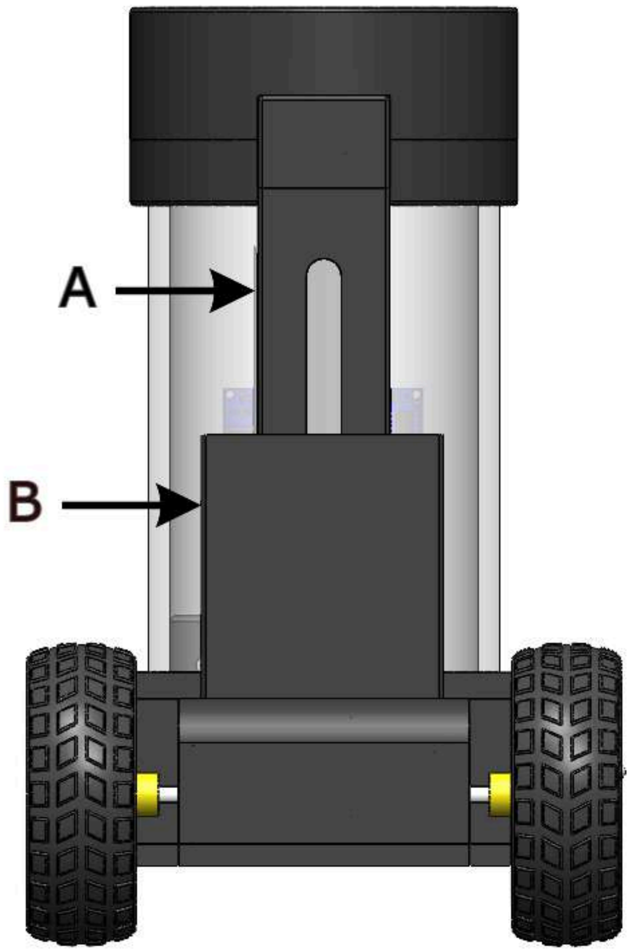


1. Front View of Optimum Solution



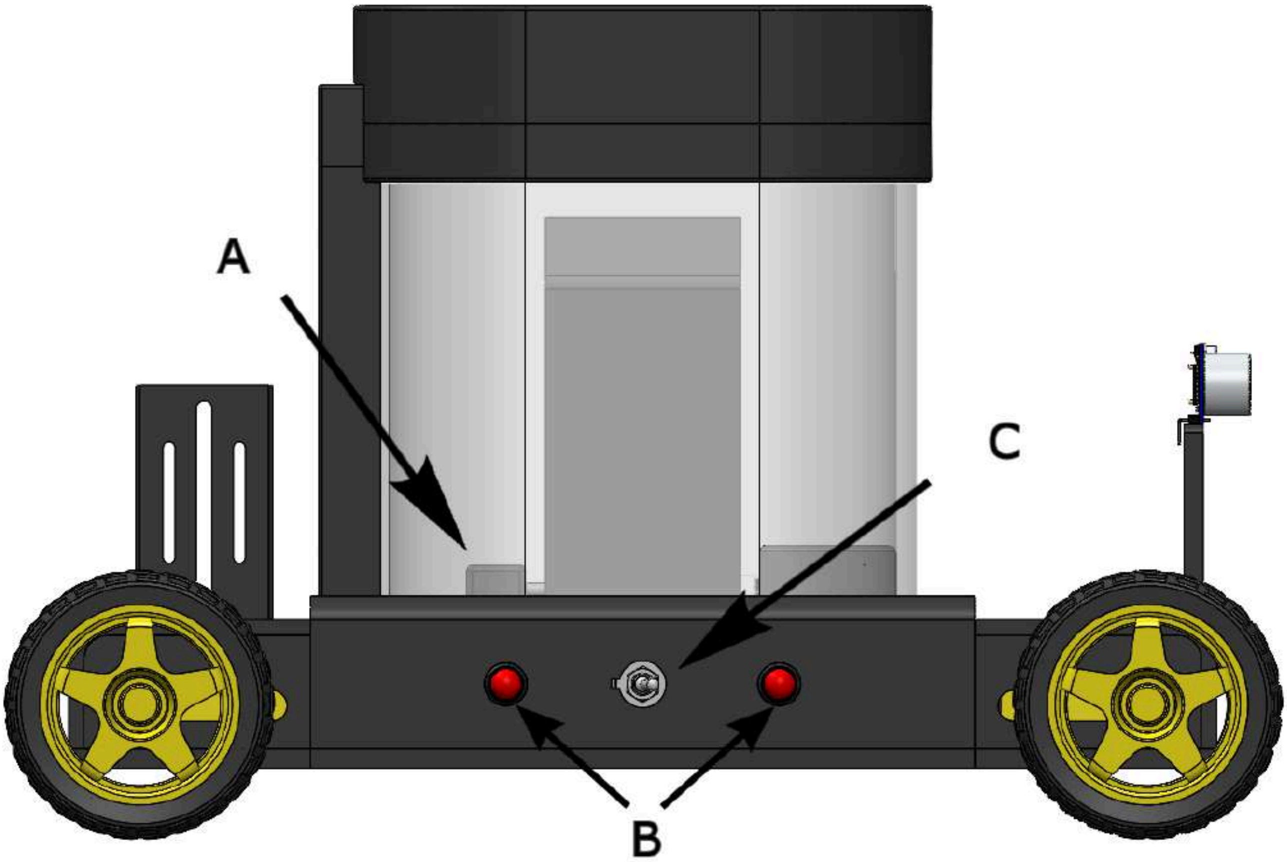
Front View Annotation Key	
A	The Ultrasonic Sensor (HC-04) will be able to detect movement from other objects, allowing it to avoid them and search for the best possible route without any interference.
B	The 2 Gearbox Motors were positioned at the side of the housing which will allow for better movement and rotational speed. Wheels as shown in the diagram were picked for better grip with uneven surfaces etc.
C	The wheelchair platform has a sloped edge at the side to allow people with limited ability to get on seamlessly (eg. wheelchairs and scooters)
D	The Ultrasonic sensor has a structural support made off from acrylic to allow it to detect objects that it may not see due to its restricted field of view.

2. Rear View of Optimum Solution



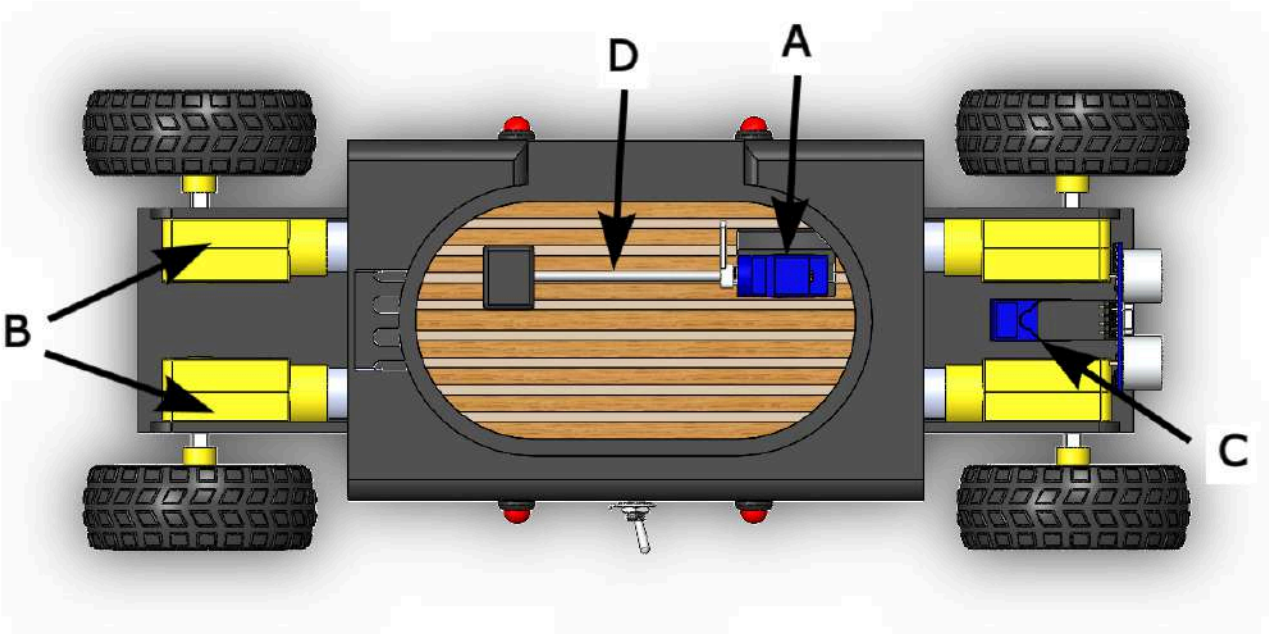
Rear View Annotation Key	
A	The wire chamber with the glass window makes it easier to see what cables are being used for the project and where they are positioned so it's easier to identify which component they are connected to.
B	The battery chamber is positioned on the back motor housing so it wouldn't cause interference with the back motors. This makes it easier to disassemble and charge the batteries when needed.

3. Side View of Optimum Solution



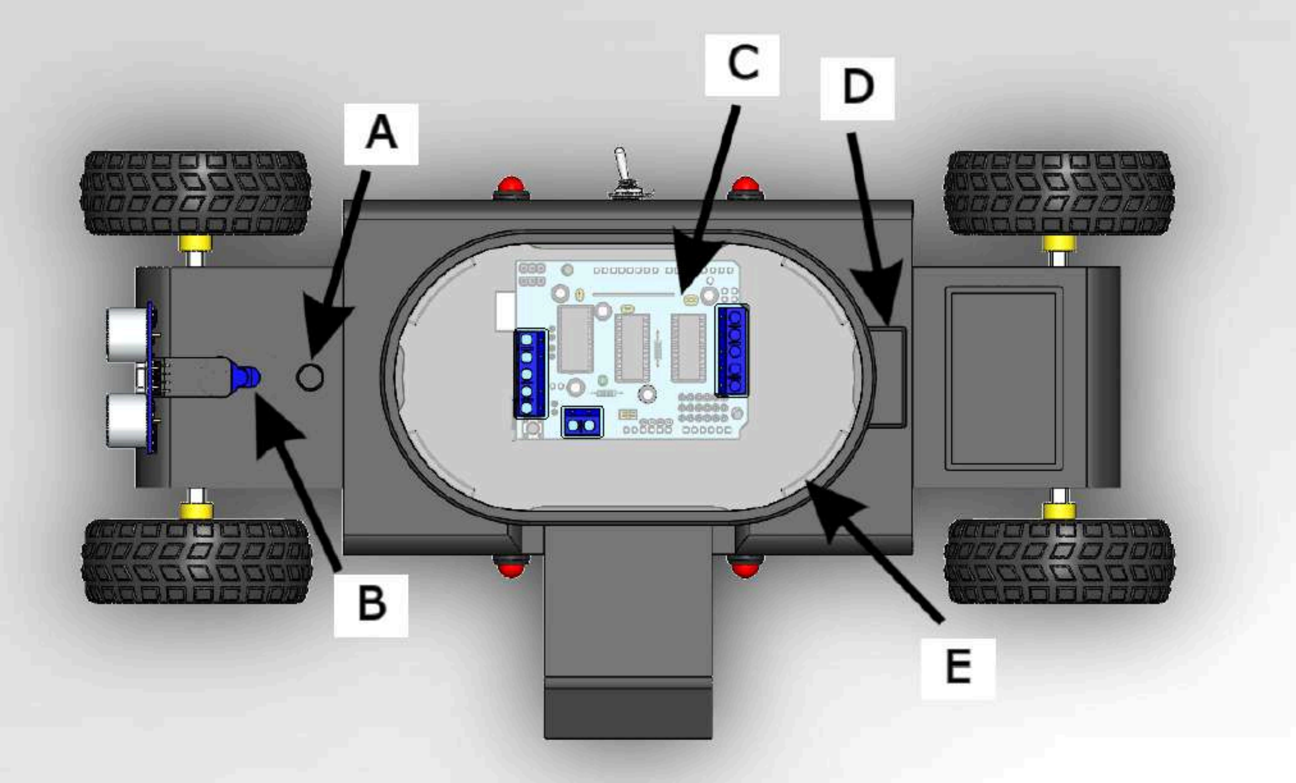
Side View Annotation Key	
A	The accessibility platform has a stabiliser so the platform does not collapse when passengers get on the vehicle without any issues. The stabiliser also acts as a backup when the platform is rotated back to its original position as shown in the diagram.
B	2 LEDs are positioned at each side so each LED will correspond to the motor that is turned on to give the vehicle some awareness to outsiders and provide easier accessibility if the vehicle is turned on or not and if it's safe to get on the vehicle.
C	The SPST is positioned here so the vehicle can be turned on when required.

4. Section View of Mechanism of Optimum Solution



Section View Annotation Key	
A	A Servo Motor is connected to the retractable mechanism as shown in the diagram. The servo motor can be programmed accurately to determine the angle of rotation needed and can act as a door when the platform is rotated back to its original position automonously.
B	The vehicle is powered by 4 motors so it can drive easier with better rotational speed and better stabilisation. For the project I will be powering it using 4 Gearbox DC Motors.
C	The Ultrasonic Sensor is connected via Servo Motor so the sensor can rotate at both sides, checking left and right, so it can see if it's safe to go in whatever direction it finds without any interference.
D	An aluminium rod is connected to the retractable mechanism for better stability and better rotation when the platform is under load.

5. Top View of Optimum Solution



Top View Annotation Key	
A	The hole is to allow the Ultrasonic Sensor (HC-04) to pass through and to be extended when it rotates.
B	The servo motor for the Ultrasonic sensor will be positioned here so it's easier to look around with a better field of view.
C	The Arduino Uno R3 and the L293D Motor Driver Shield are positioned here so it has a vast amount of space to neatly store cables without causing other wires to interfere with each other which may cause a short circuit. Mounting pillars were added on the Arduino R3 so the board is stabilised when in use and it allows the board to be disassembled easily when the power and cables are safely dismantled.
D	The wire chamber is positioned here so it is inline with the glass casing and has a stable foundation to be supported on. Due to its position, it provides extra support to the casing and it allows further stabilisation to the board parts that are situated above.
E	Structural Supports were added to the base to allow the board casing to be easily opened. This allows the board to be more accessible to use whenever changes are needed.

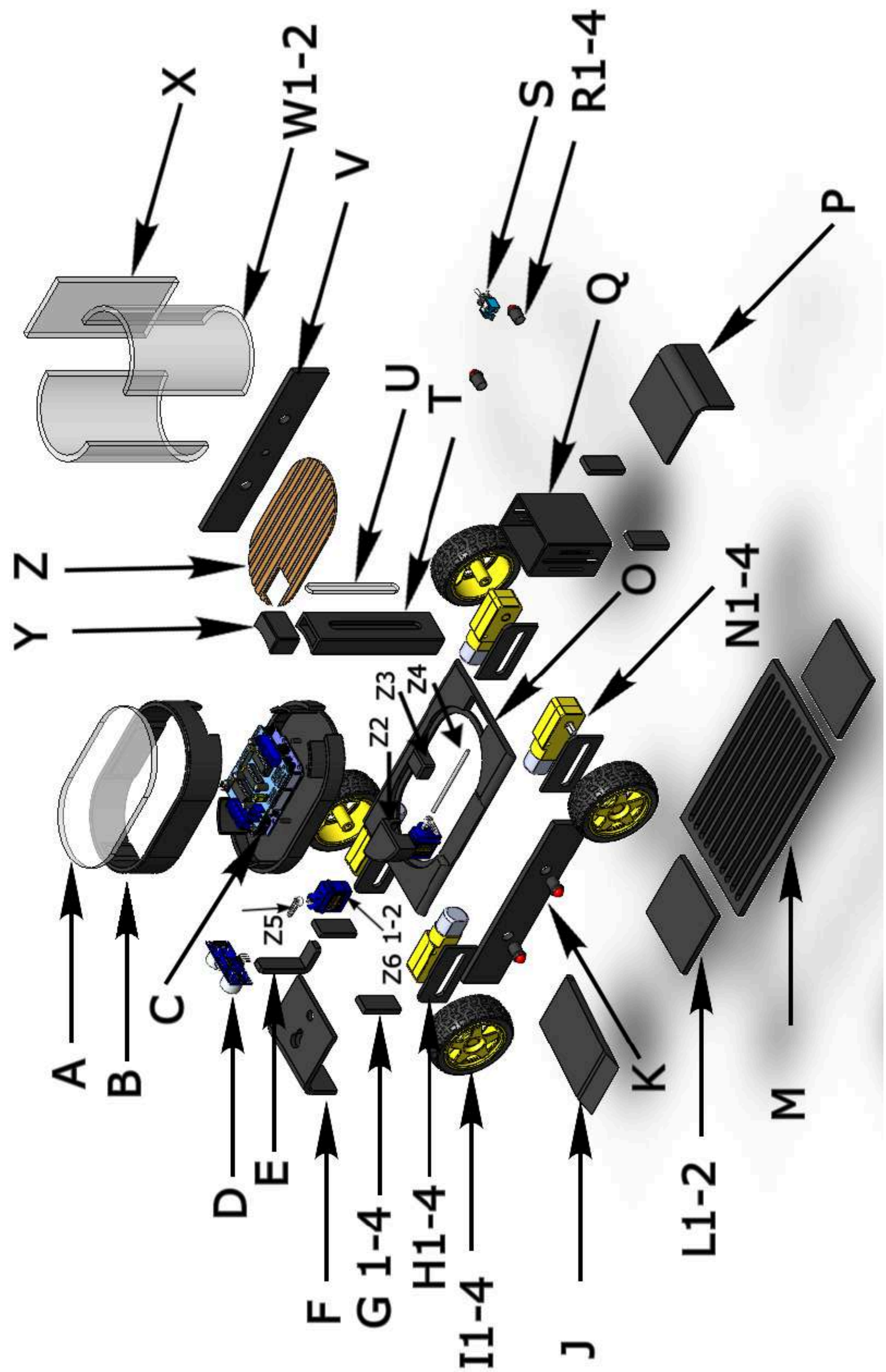
5.3 Justification of Optimum Solution

I chose this idea as my optimum solution for the following reasons:

1. I believe that the optimum solution satisfies the given thematic brief as it is a working model that could be of benefit to a person with a disability.
2. I believe that I can manufacture and produce the design and concept in the given timeframe and budget.
3. The design is based on the concept design of the Campus Shuttle shown on page 19. The design has shown to be the most suitable for my concept and the most suitable to align with the thematic brief.
4. I like the concept design for the following reasons:
    a. It can avoid obstacles in the way using sensors and allow some clearance for passengers that cannot manually control.
    b. It allows mobility users to get on using the retractable platform that autonomously rotates back and forth when needed.
    c. The design is minimalistic and modern to look at.
    d. The design is suited to the purpose it is made for and it should be able to carry out its functions effectively and efficiently without any interference.
5. All designs and concepts are prone to have some design flaws that may cause some problems but I feel that my design should not have that many major problems due to design reworks and extra structural supports. However, I do recognize the following problems that might arise in my project:
    a. The wheels may come loose when under load.
    b. The ultrasonic sensor may not pick up every obstacle that is lower/higher than its field of view and may end up colliding with other objects and may cause damage to the vehicle.
    c. Dust or other debris may cause the wheels to lose grip and less traction with different surfaces.
    d. The 3D Printed Parts may have some issues when painting, since some surfaces are uneven and may cause some issues when assembling.
    e. The vehicle may have a power limit due to Arduino's limit of 5V and power for the L293D board.

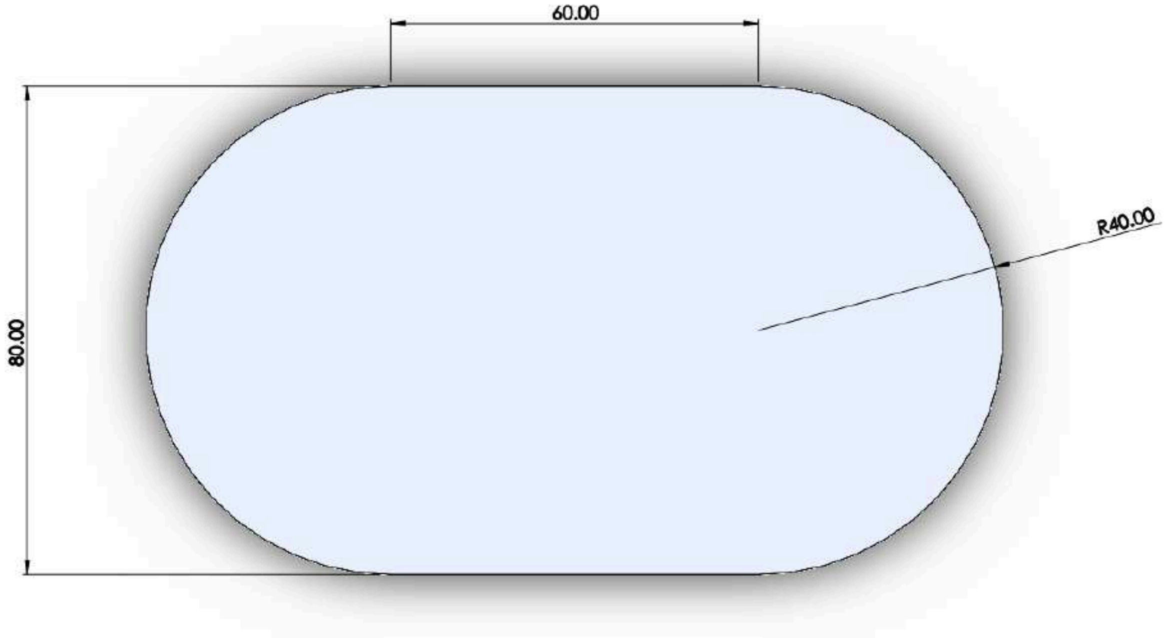
6. Sketches and Drawing for Manufacture

6.1. Scaled Exploded View

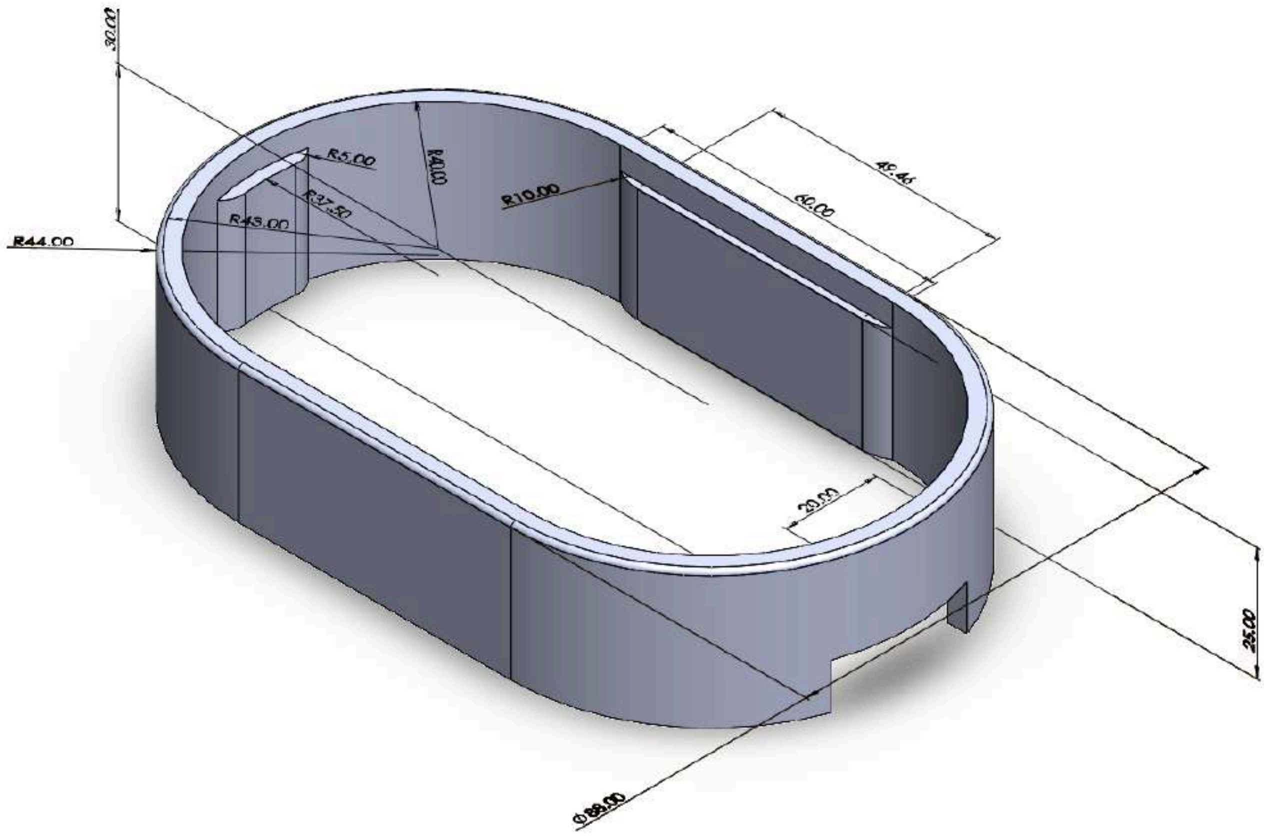


6.2 Individual Part Drawings

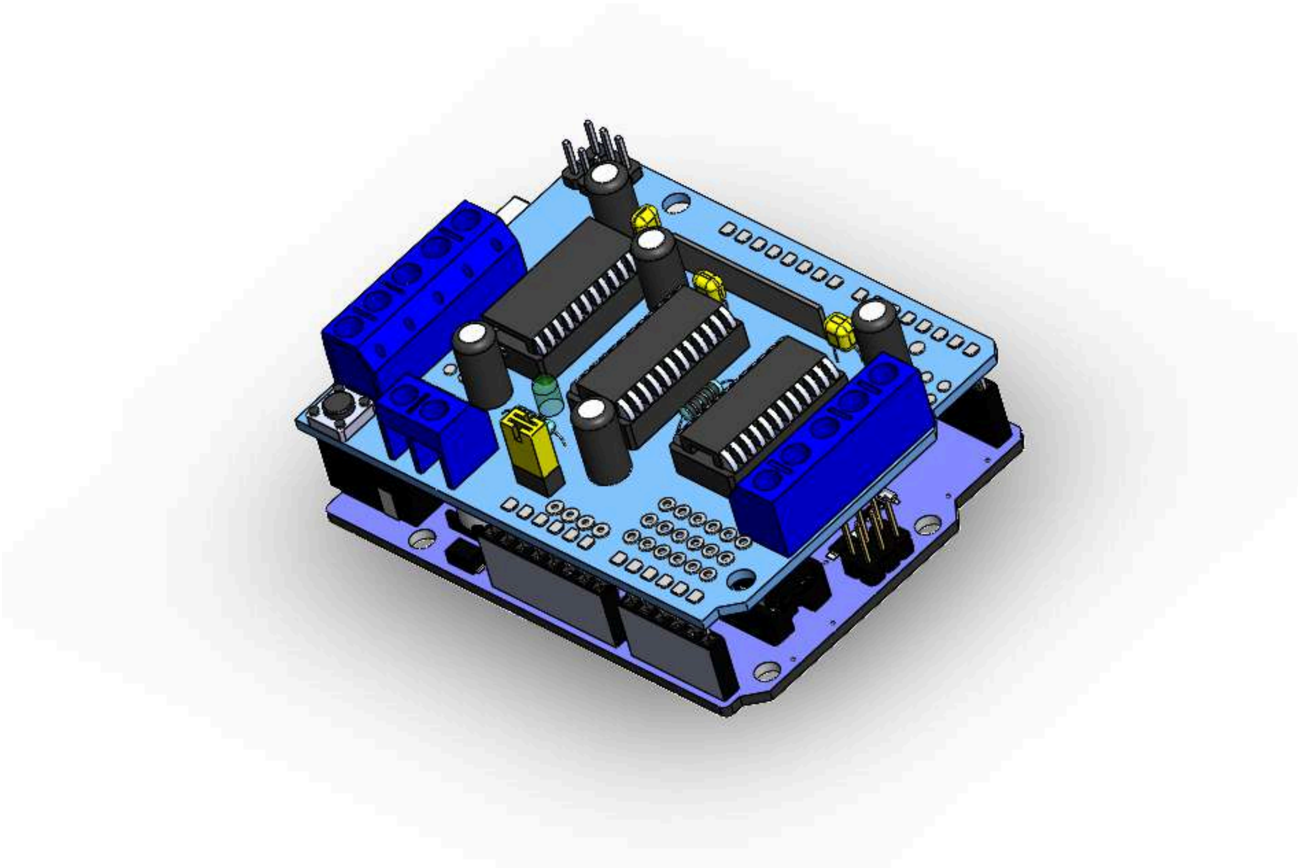
A (Glass Top for Board Casing)



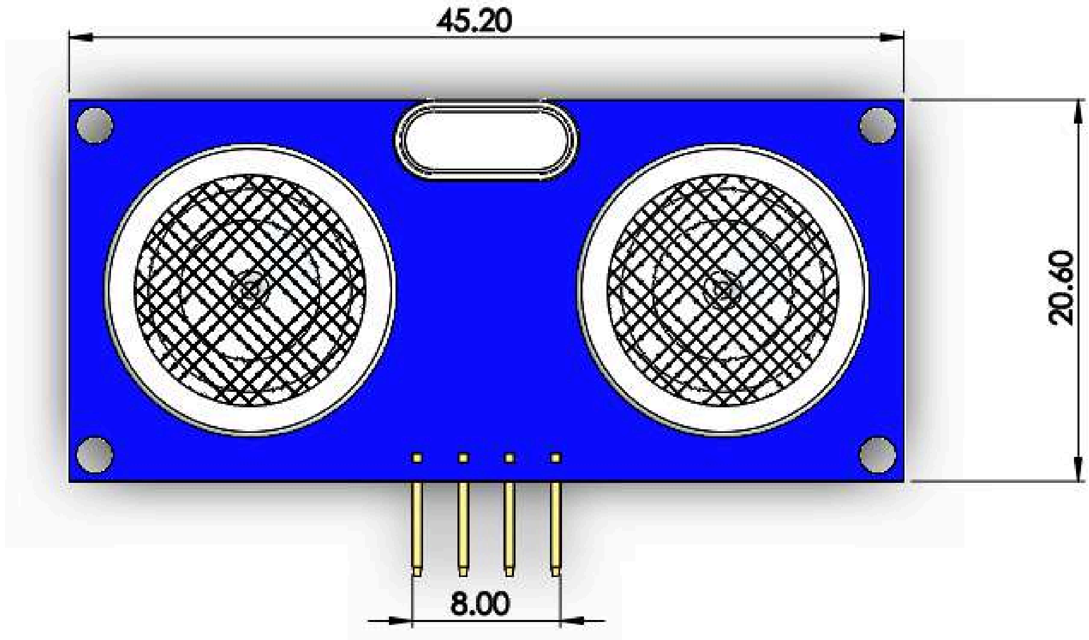
B (Top Piece for Board Casing)



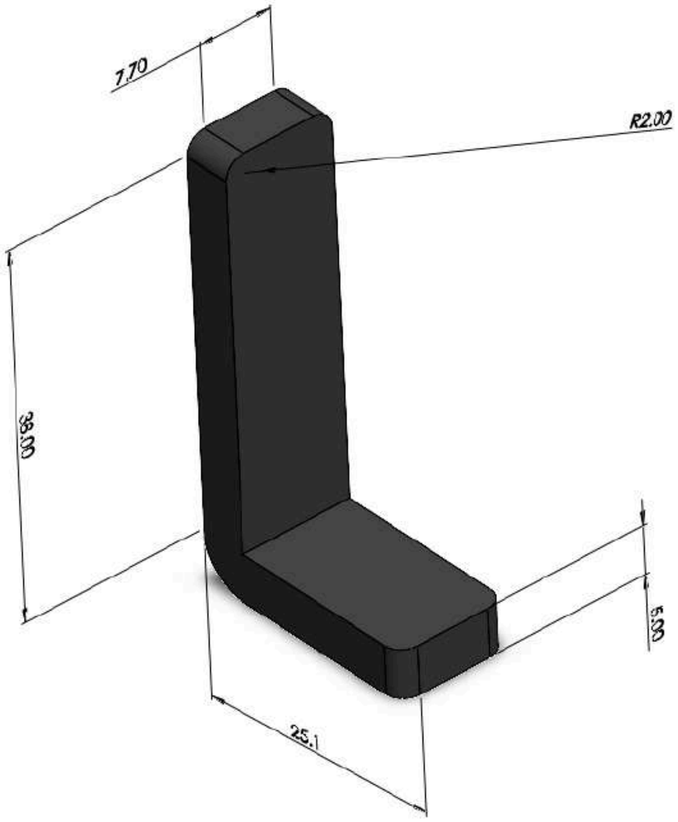
C (Arduino Uno R3 + L293D Motor Board)



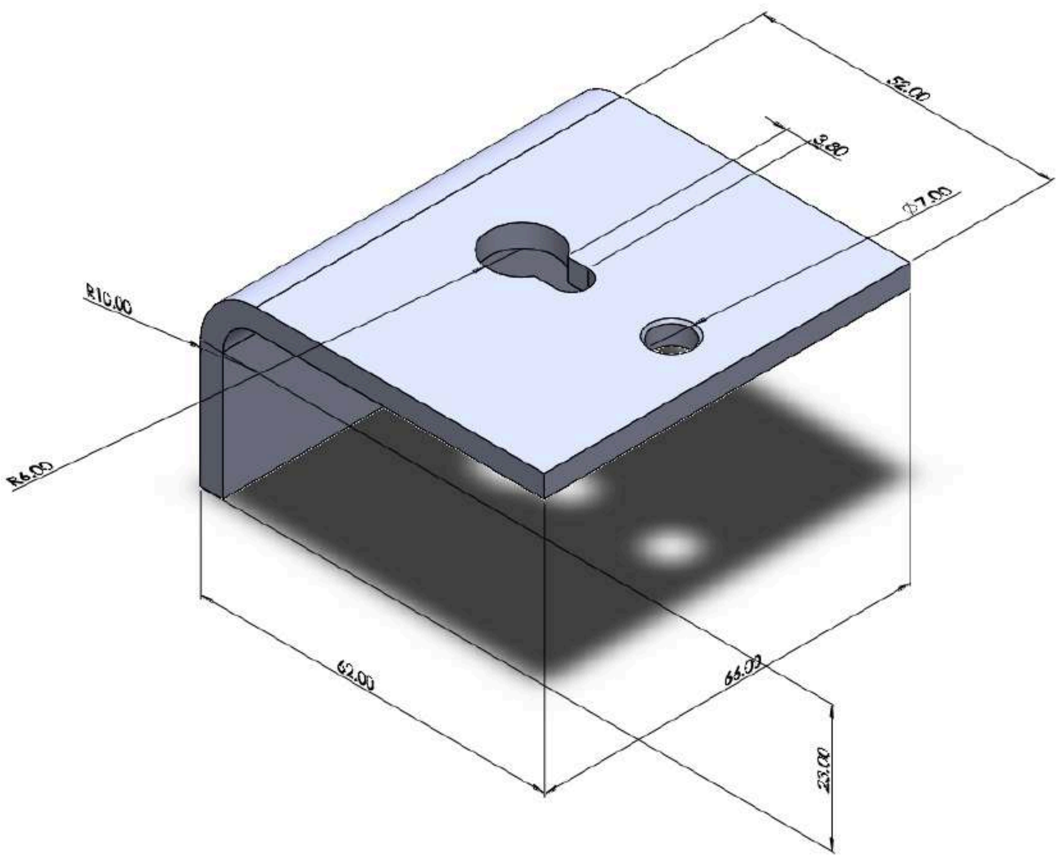
D (Ultrasonic HC-04 Sensor)



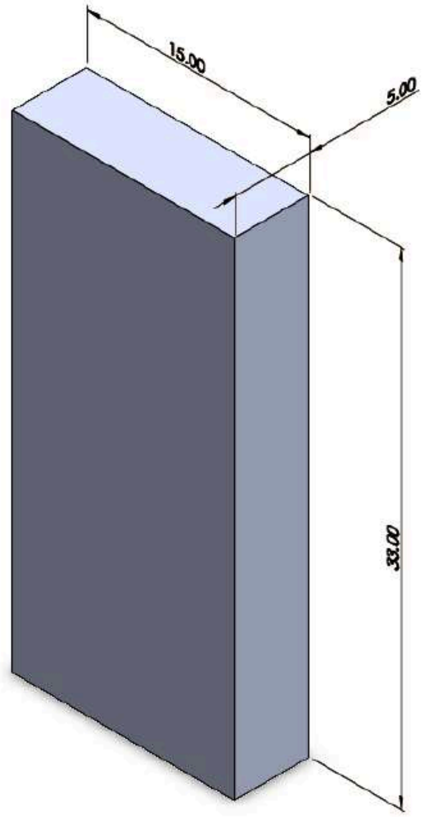
E (Ultrasonic Sensor Support Piece)



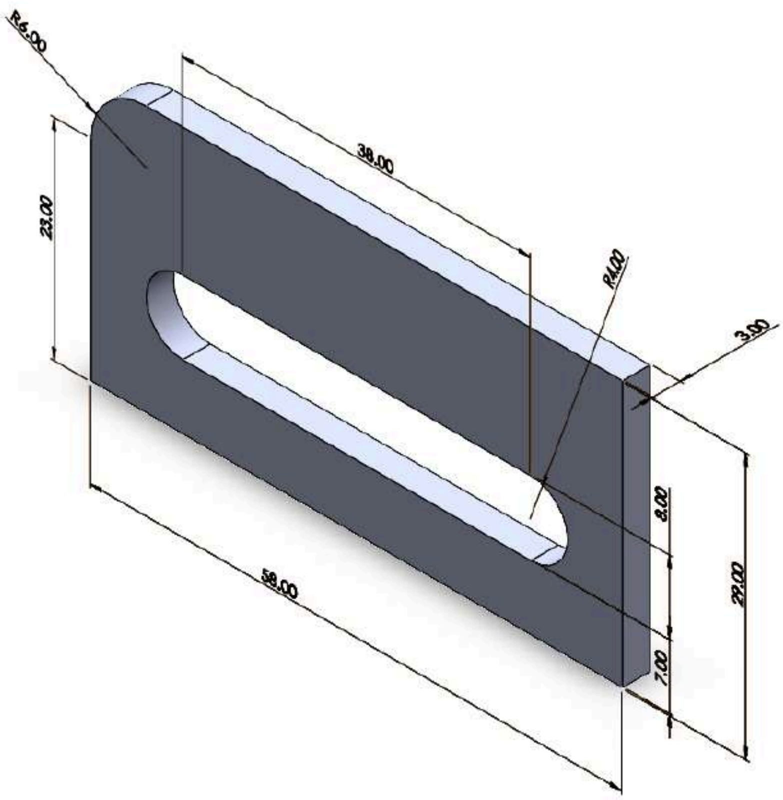
F (Front Motor Housing Piece)



G1-4 (Middle Piece Structural Supports)

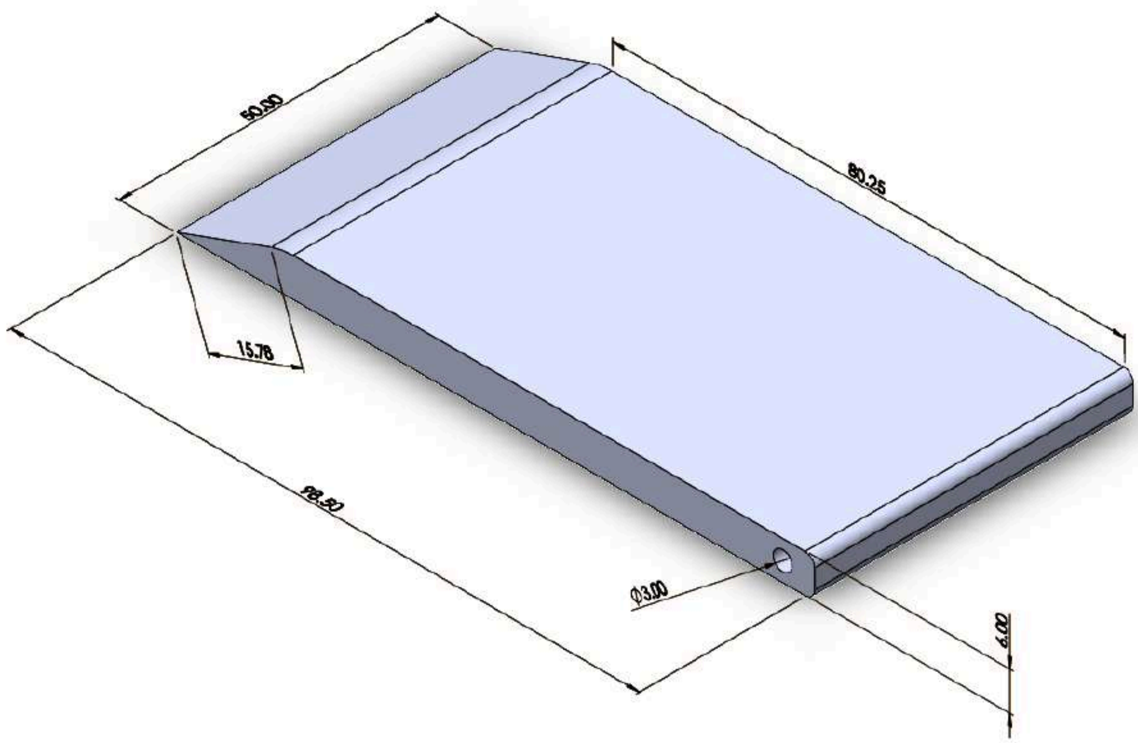


H1-4 (Motor Housing Sides)

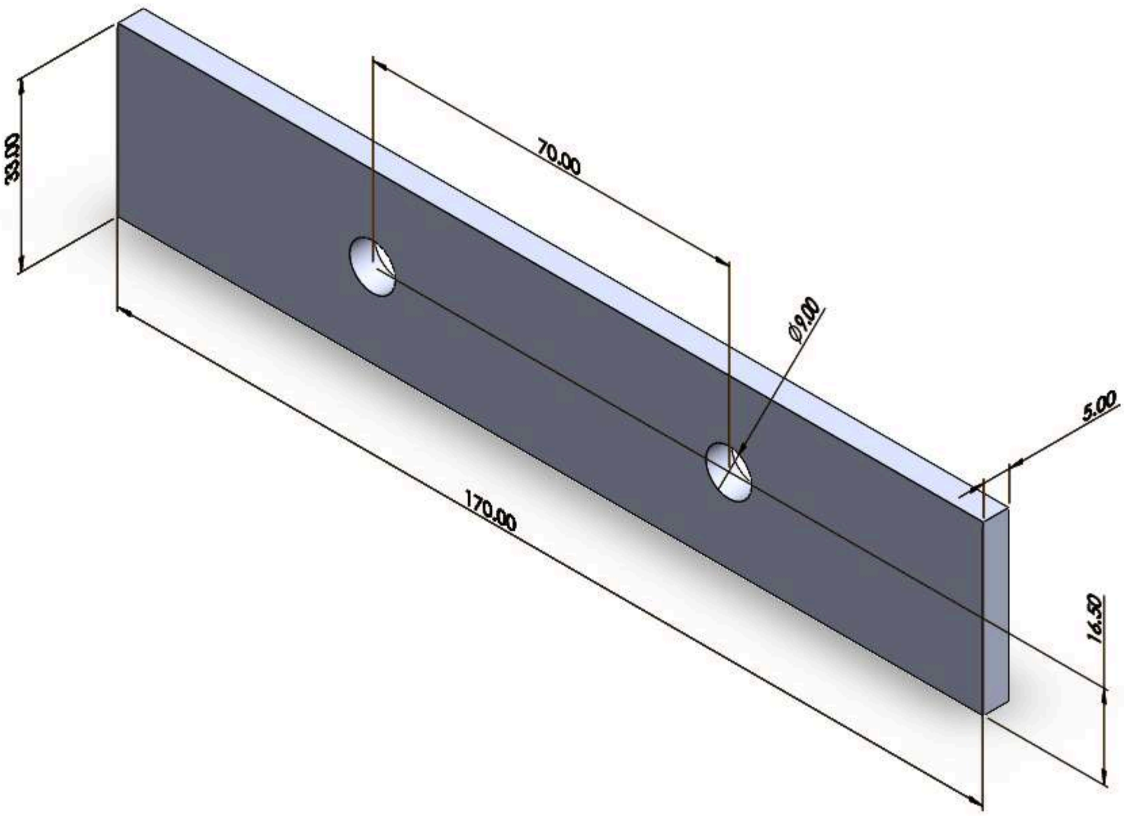


I (4x Wheels)

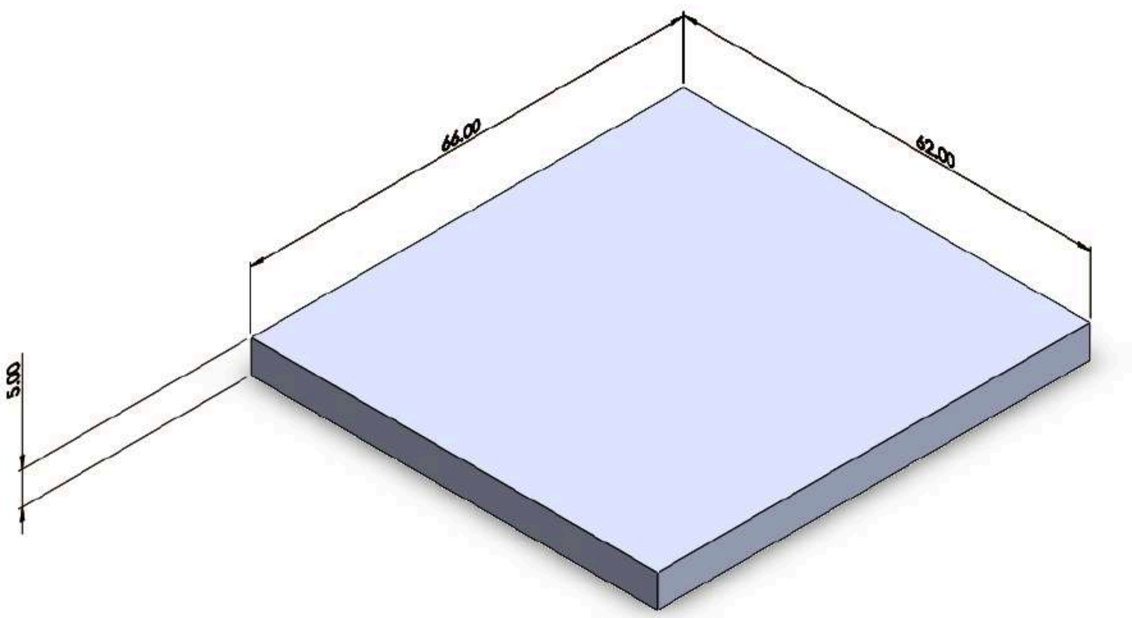
J (Retractable Platform)



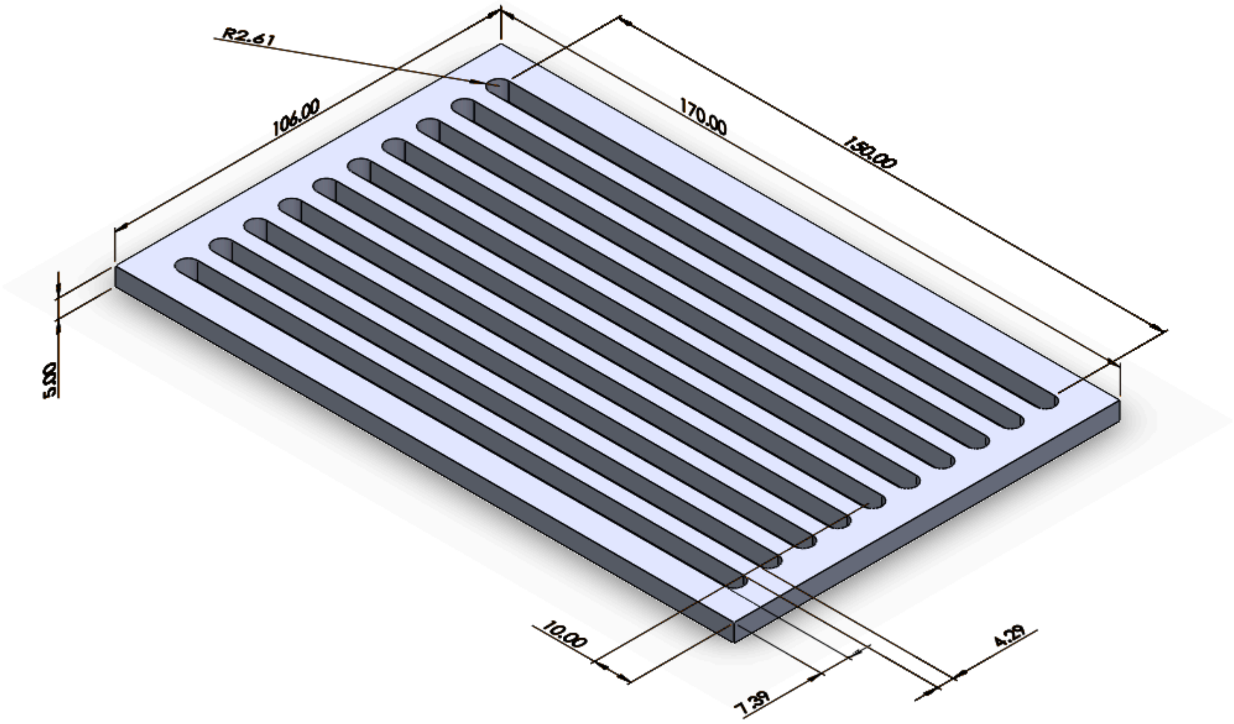
K (Front Middle Piece)



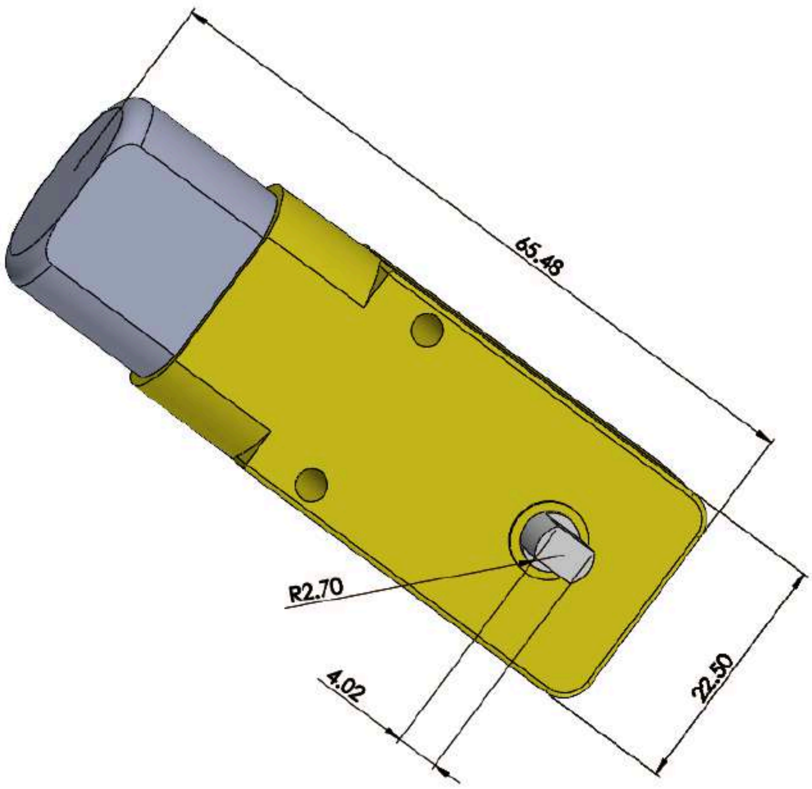
L1-2 (Base Front and Back Piece)



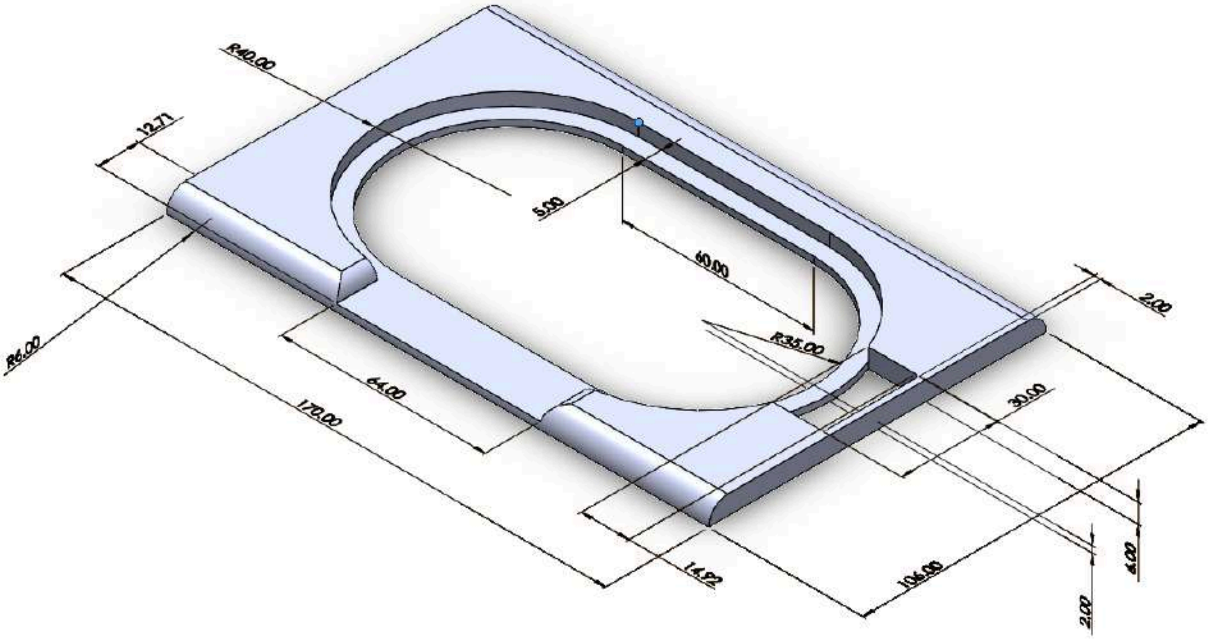
M (Base Middle Piece)



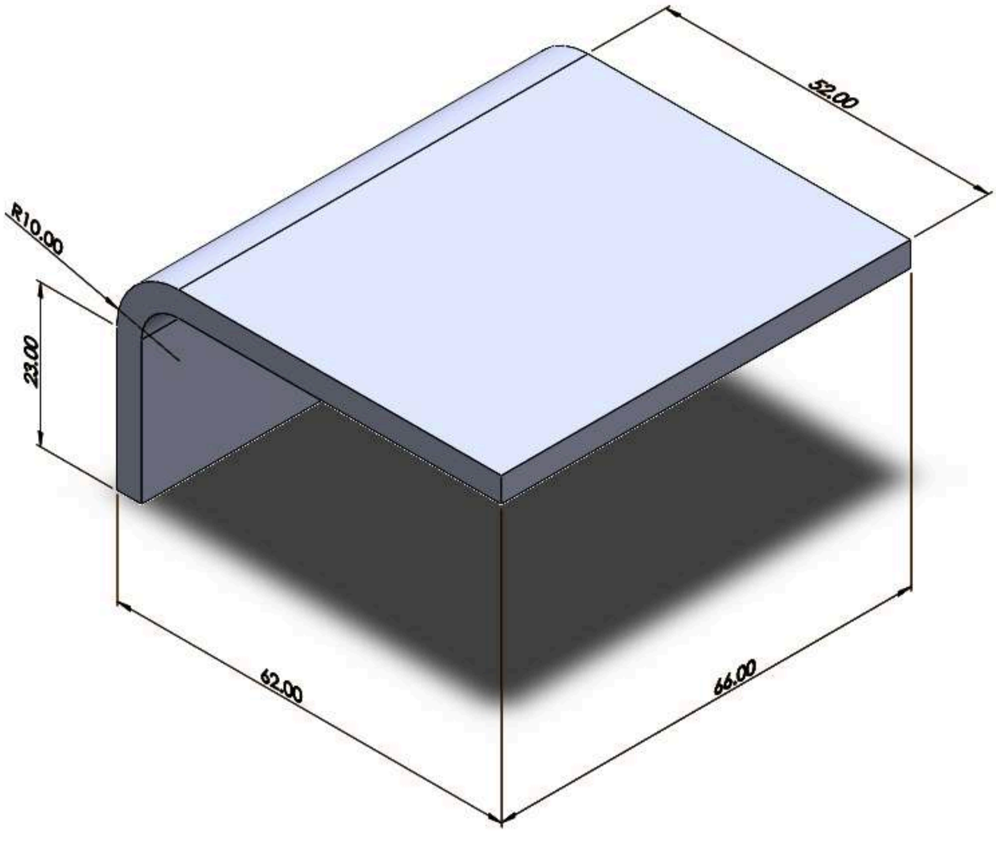
N1-4 (Gearbox DC Motors)



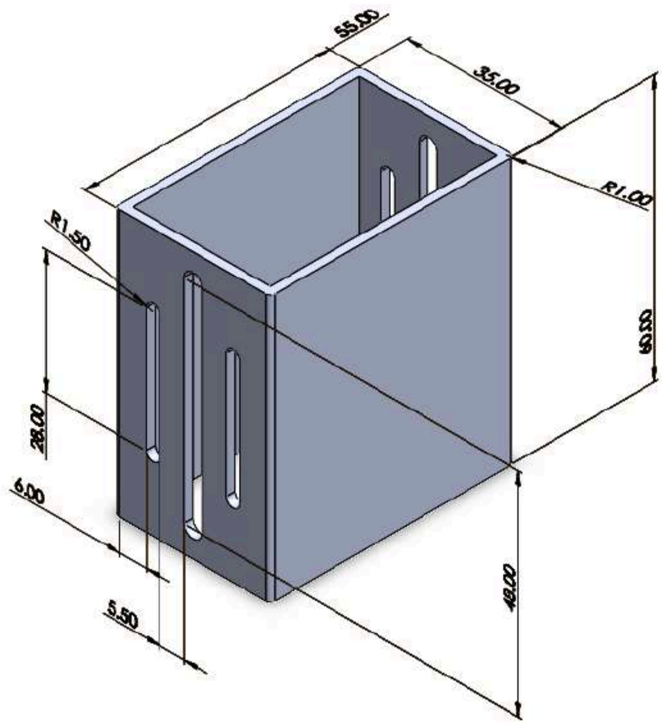
O (Base Top Piece)



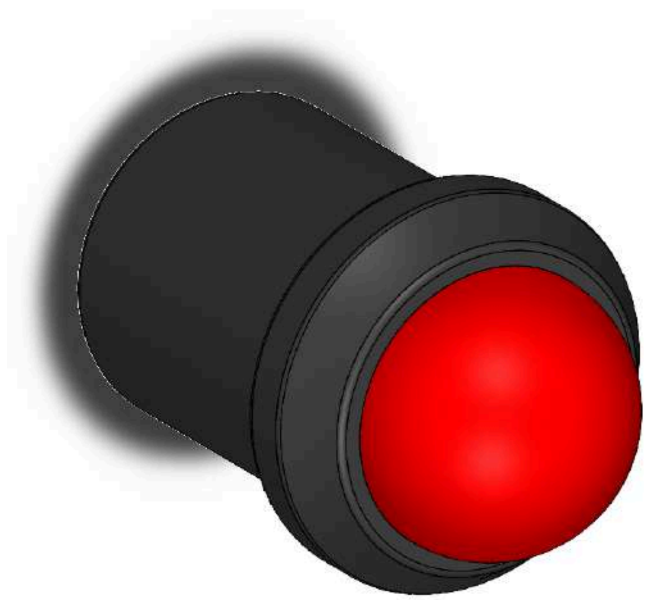
P (Back Motor Housing)



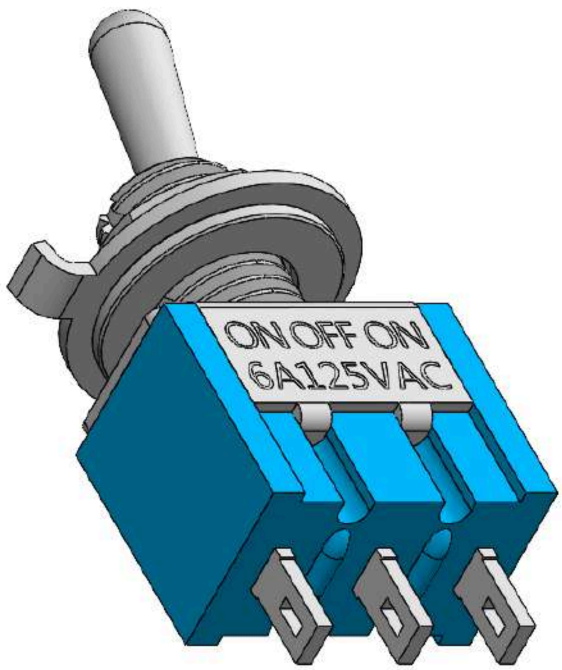
Q (Battery Holder)



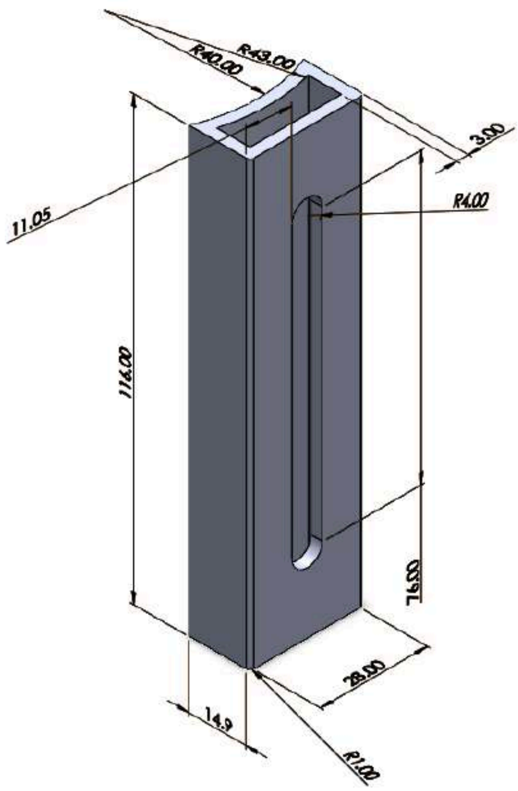
R1-4 (LED + LED Holder)



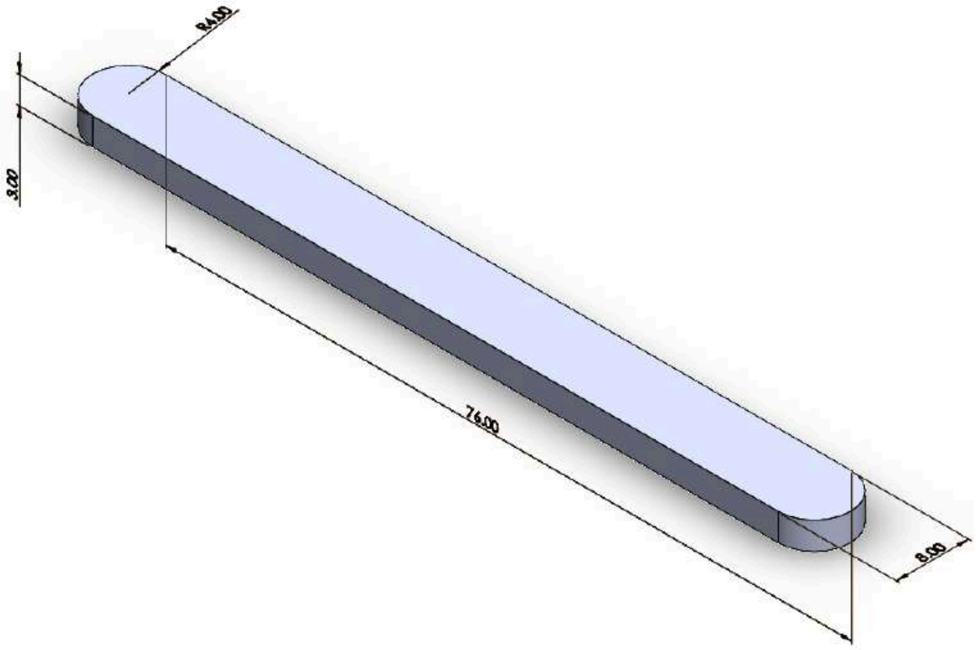
S (SPST Switch)



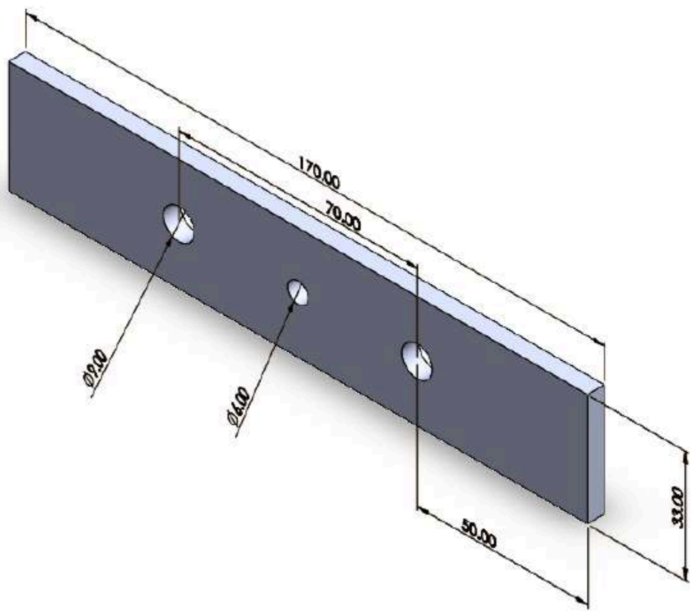
T (Wire Chamber)



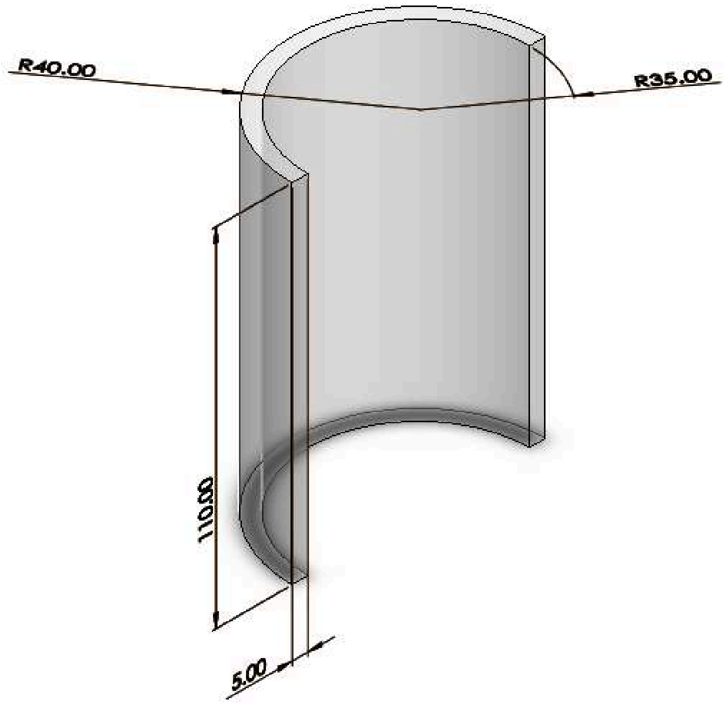
U (Wire Chamber Glass)



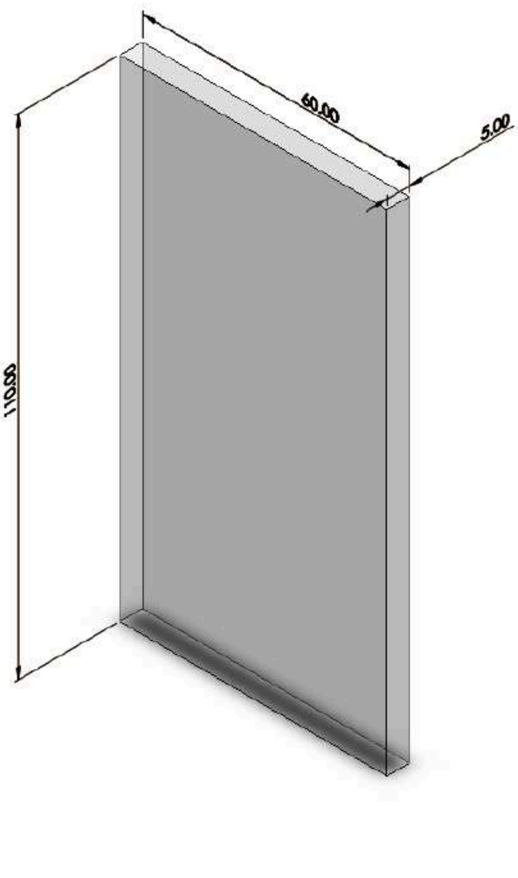
V (Back Middle Piece)



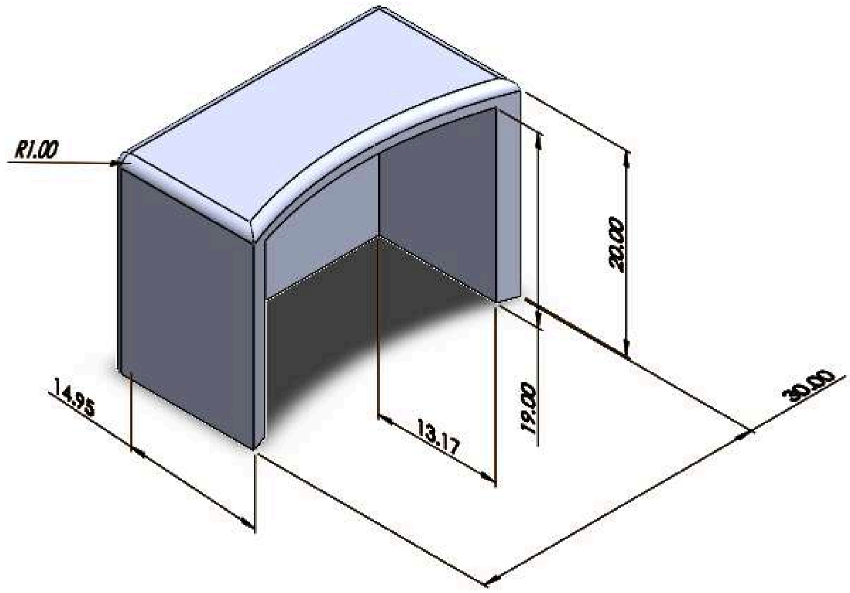
W1-2 (Glass Base Pieces)



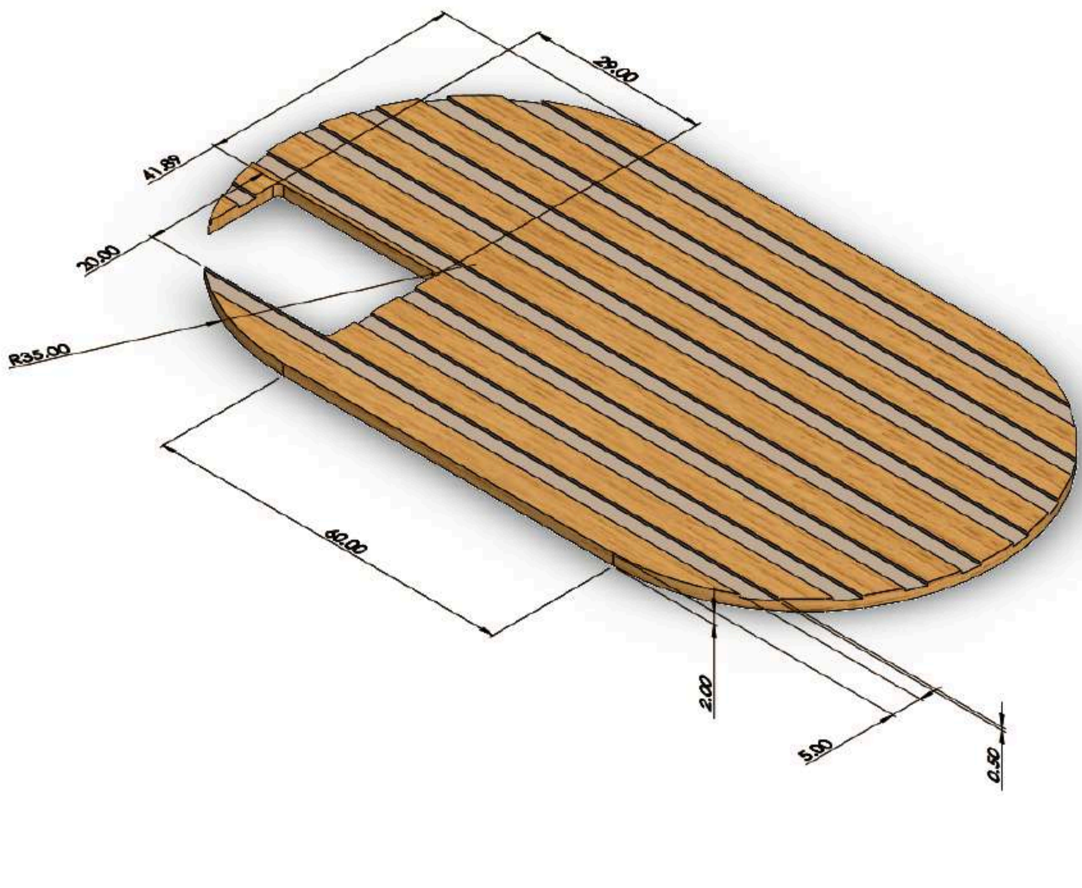
X (Glass Base Middle)



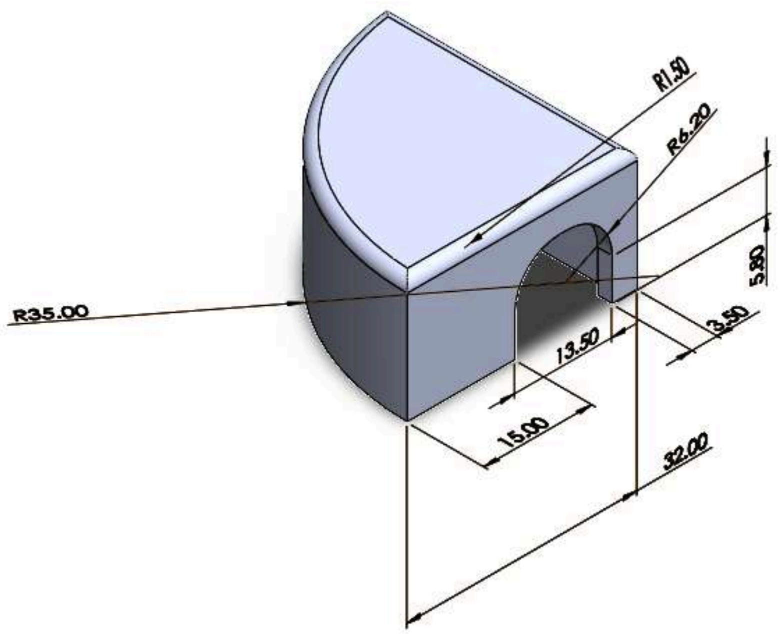
Y (Wire Chamber Top)



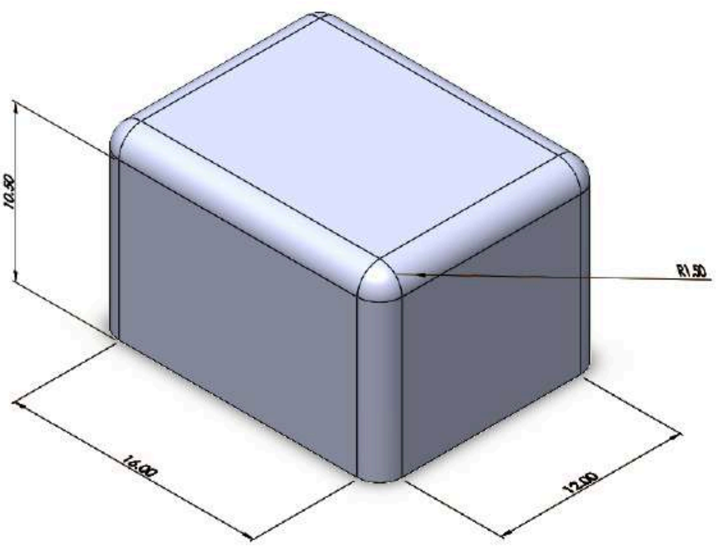
Z (Wood Base Piece)



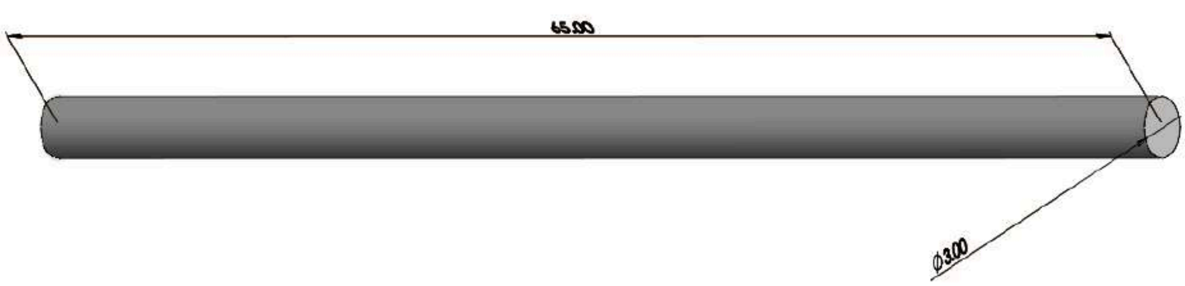
Z2 (Retractable Servo Housing)



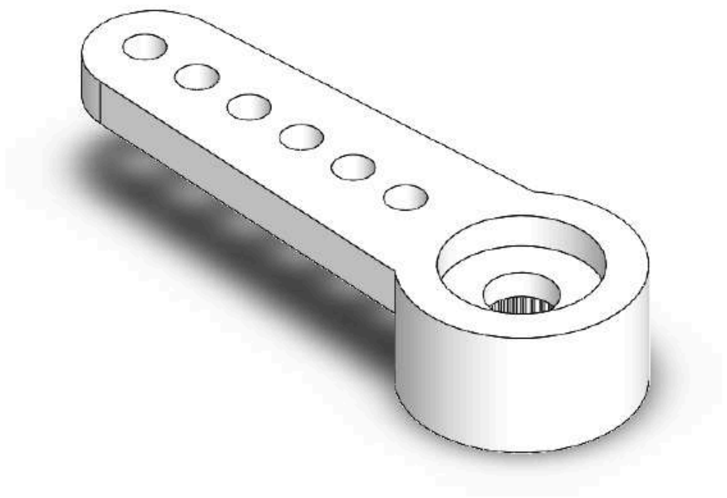
Z3 (Retractable Mechanism Stabiliser)



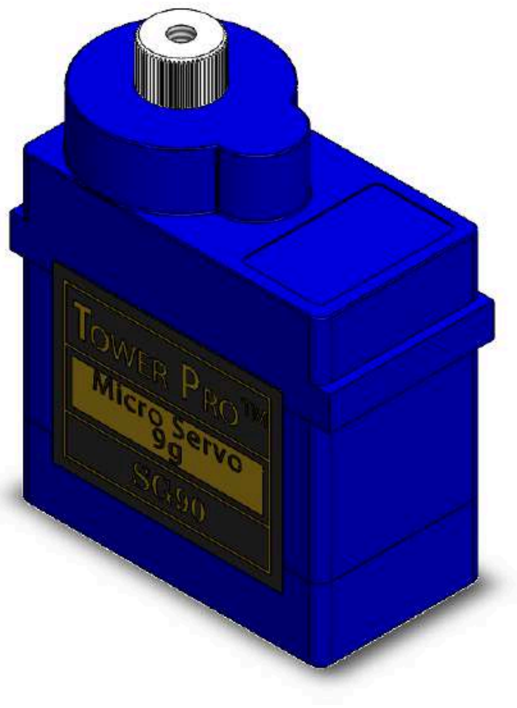
Z4 (Aluminium Axle 3mm)



Z5 (Servo Motor Rotational Part)



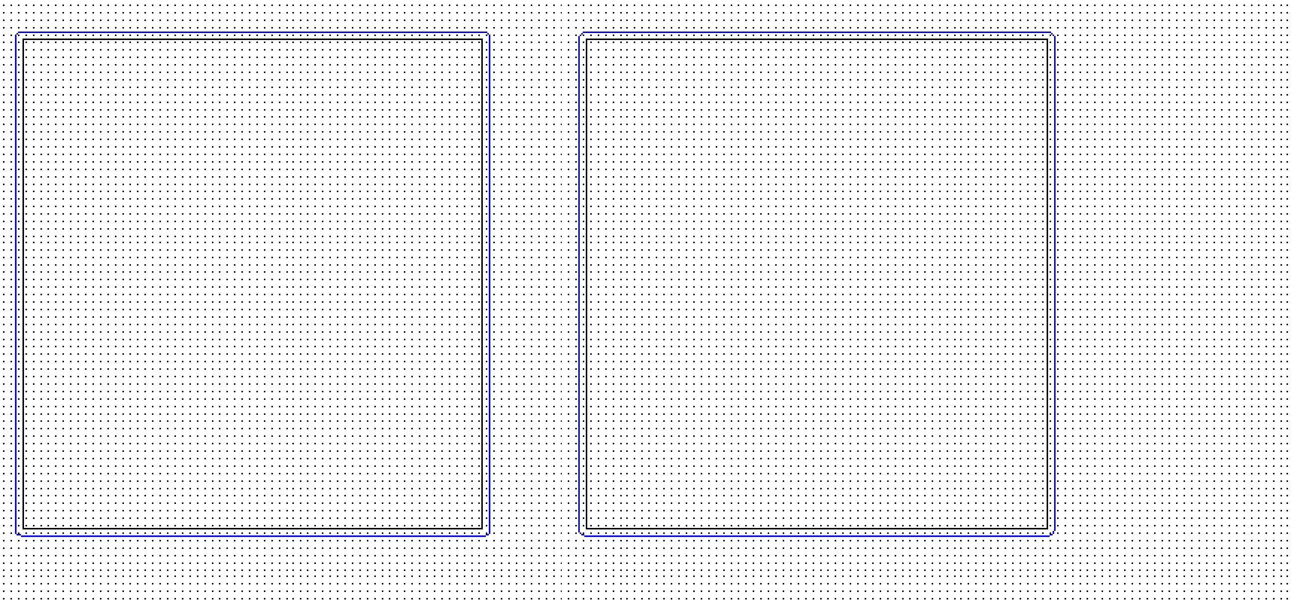
Z6 1-2 (Servo Motors)



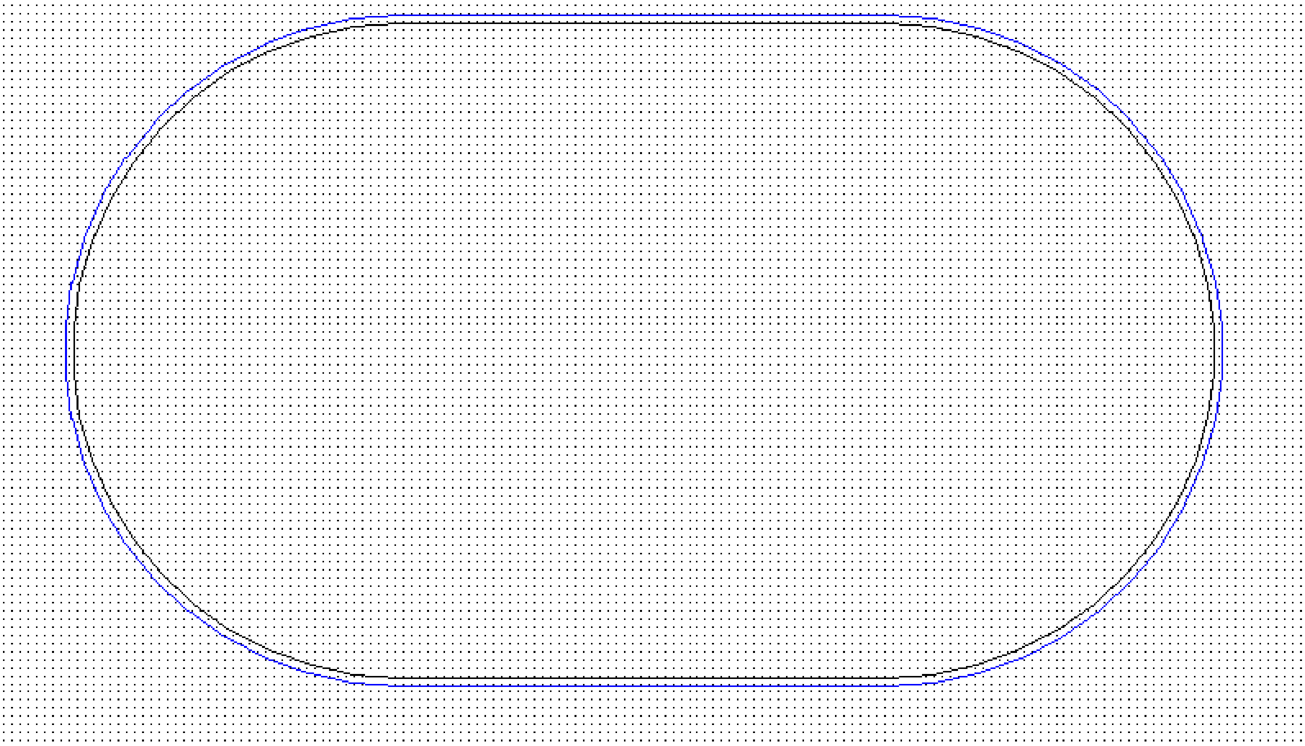
2D Design of CNC Pieces

M

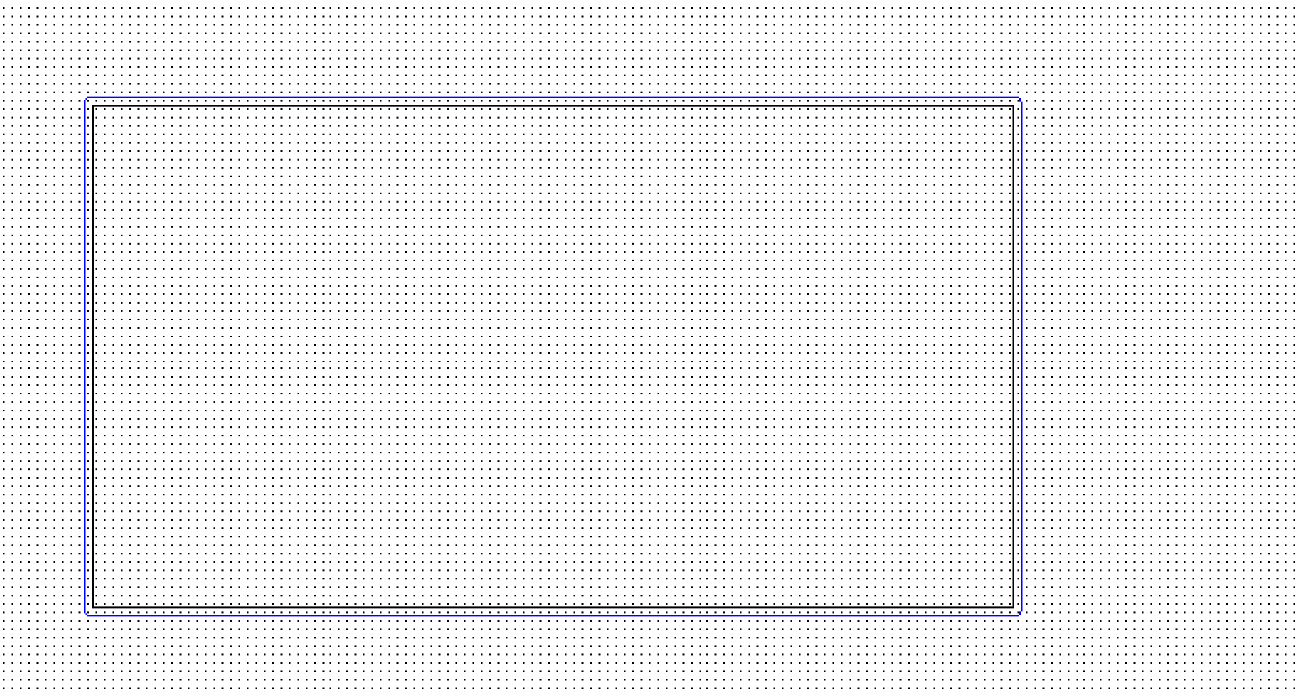
L1-2



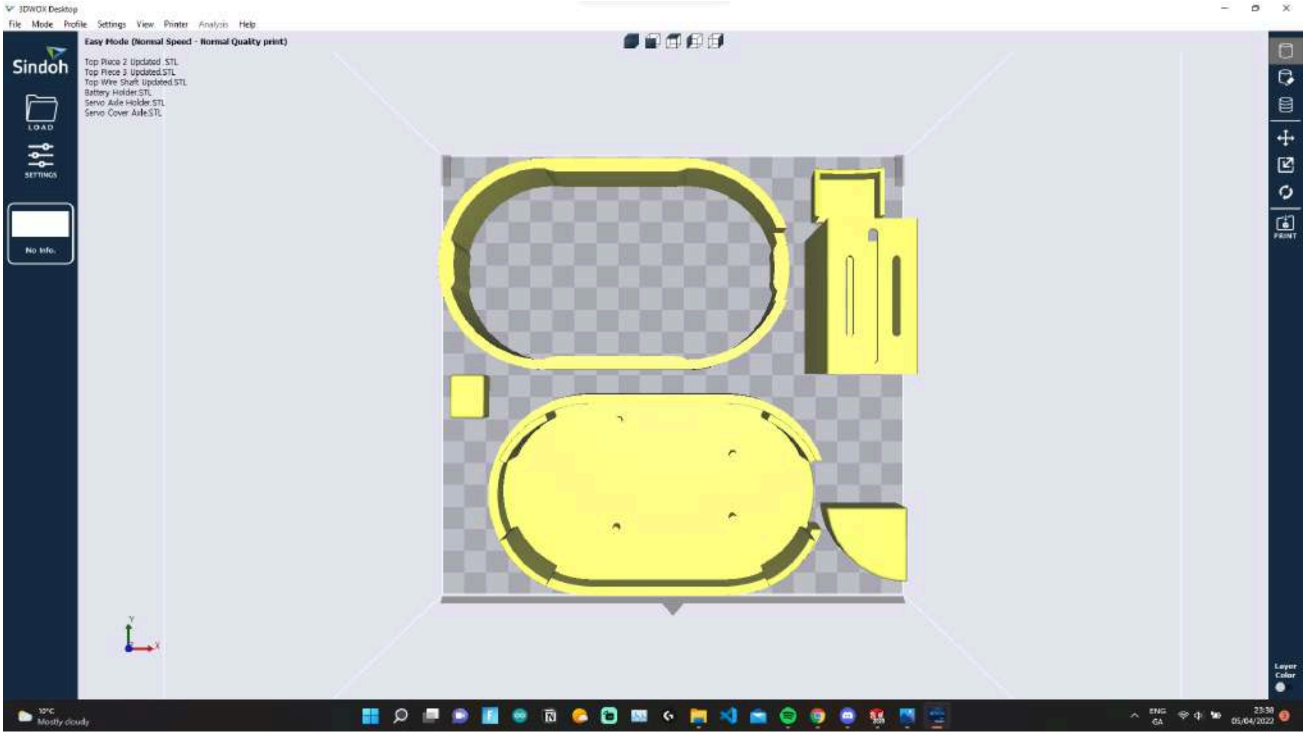
A

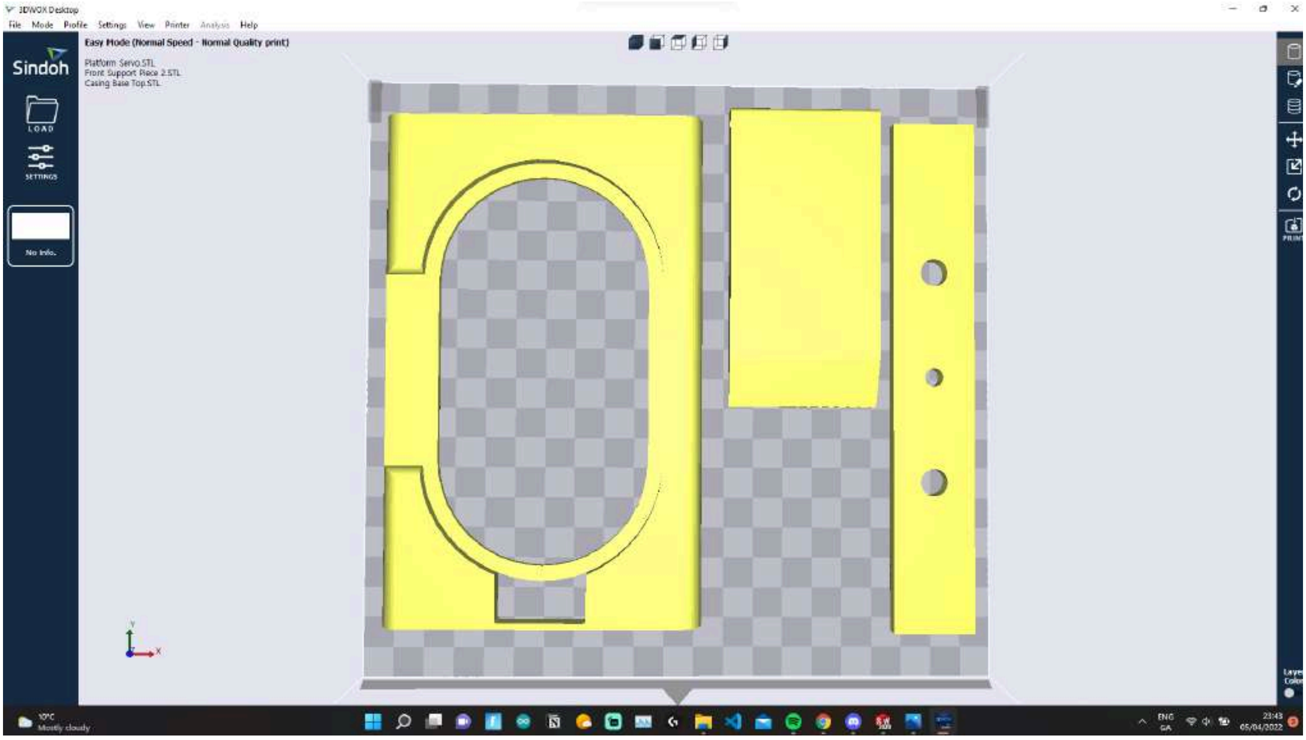


X



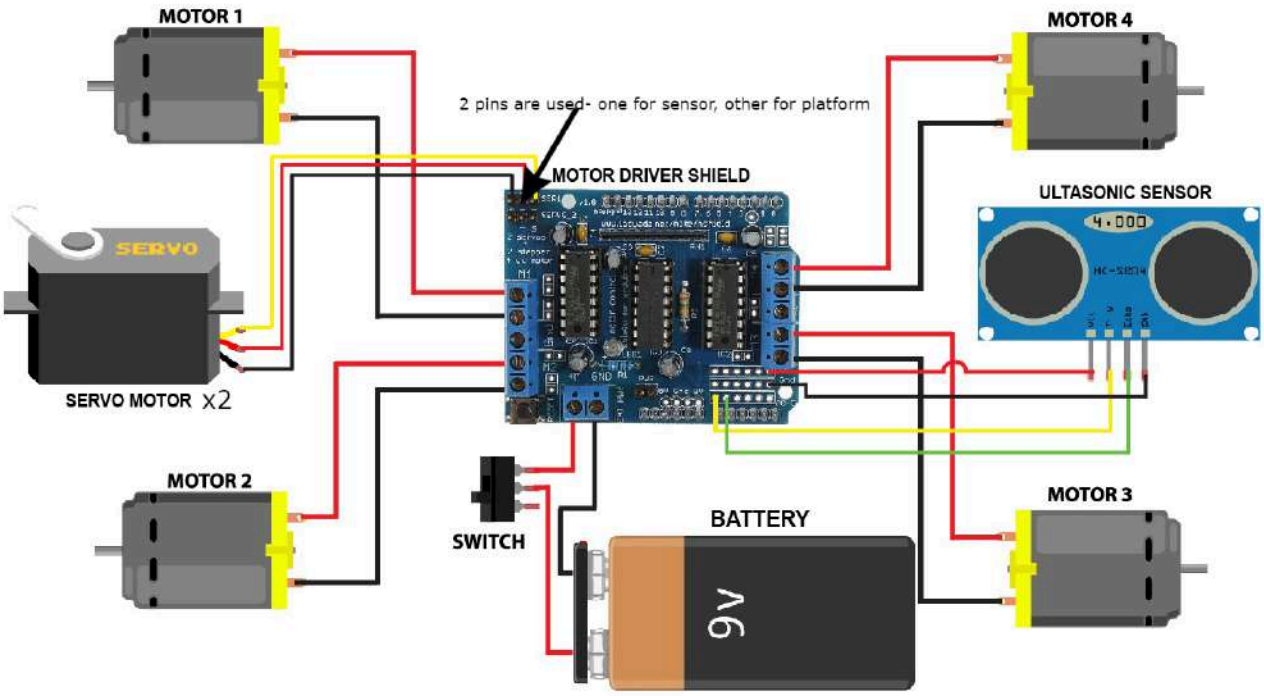
3D Files for 3D Printed Pieces



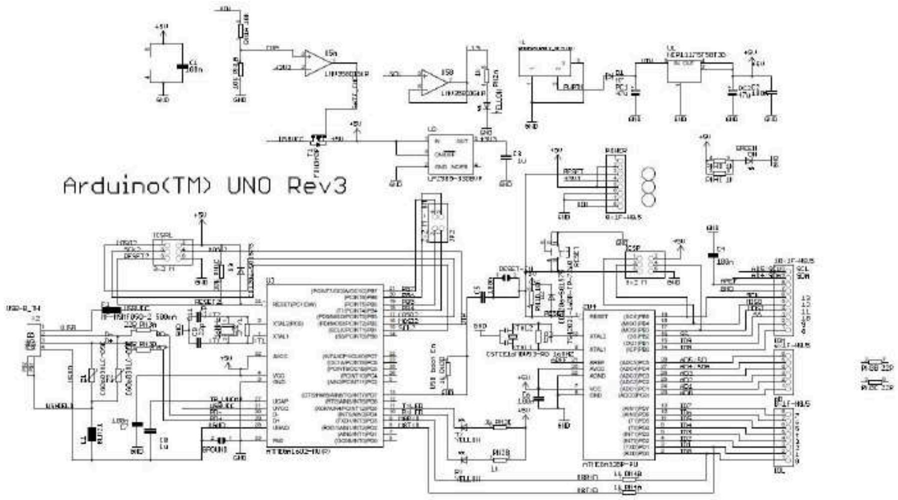


6.3 Circuit Diagrams

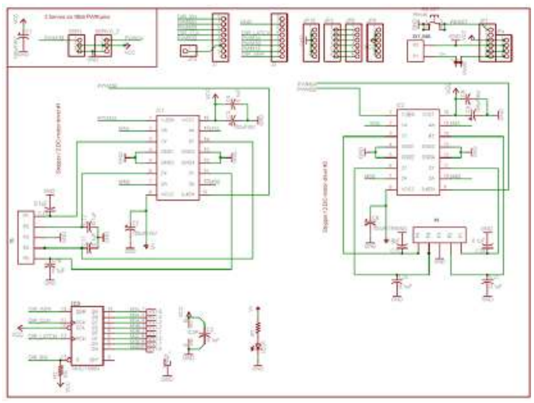
This is my circuit diagram based on the system I have prescribed in the folio:



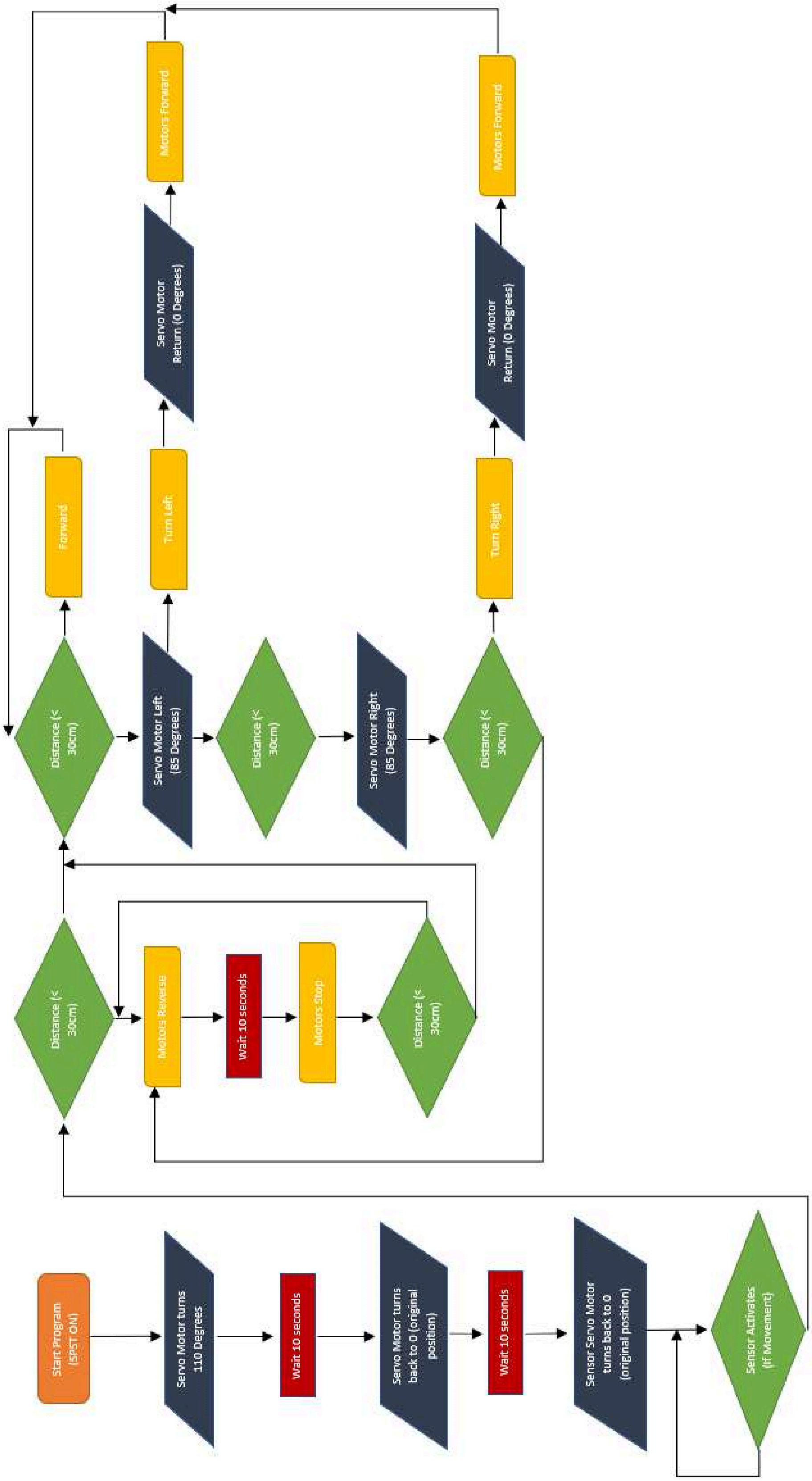
Schematic diagram of Arduino Uno R3



Schematic diagram of L293D 4-Channel Motor Driver Shield



6.4 Program Flowchart

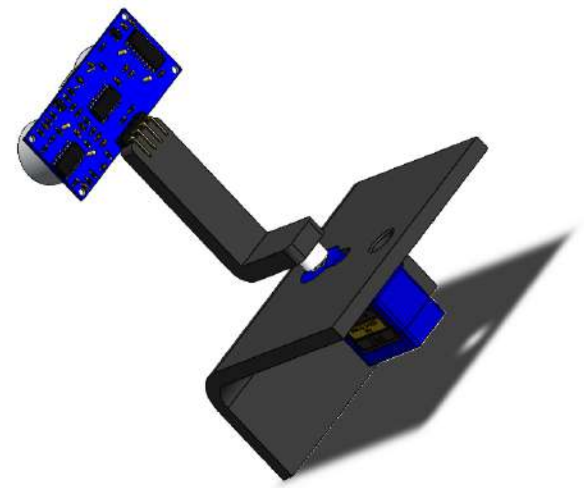


Program Explanation

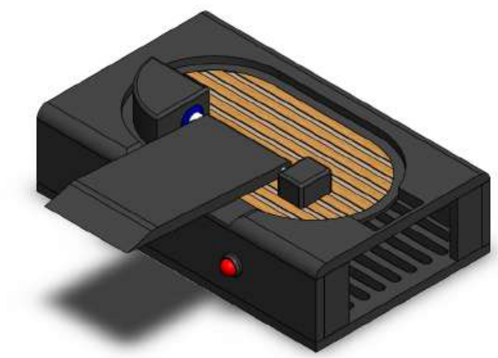
(Start)

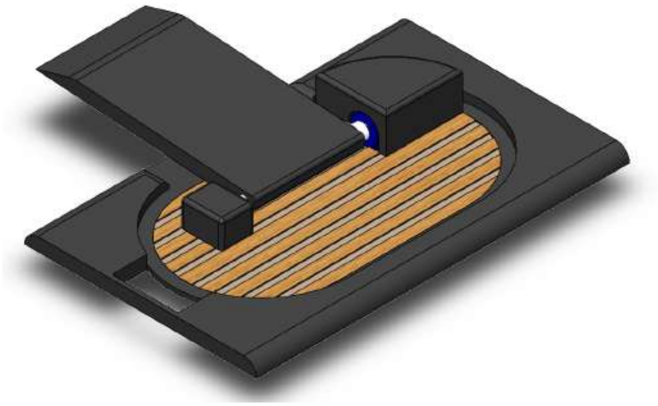
- ➔ When the vehicle is turned on by the SPST Switch, the rotational platform turns on and rotates downwards 90 degrees and stays there for 10 seconds. This allows for people with limited mobility to get on safely
- ➔ After 10 seconds, the rotational platform rotates back up to its original position and stops for 10 seconds. Rotating the platform back to its original position provides safety for the users since it acts as a door now and the system now confirms that the passengers are on the vehicle and safe to go.
- ➔ When the 10 second mark is complete, the ultrasonic sensor rotates at 0 degrees, which is straight. The sensor confirms that it is ready to go and only requires activation.
- ➔ When the sensor detects activity, the system detects that it’s ready to go and proceeds to move forward.
- ➔ If the sensor detects an obstacle within 10-20 centimetres of its field of view, the vehicle stops. This provides safety for the passengers who can’t brake due to their limited mobility.
- ➔ After the sensor detects an obstacle, the vehicle reverses back for a few seconds and stops again. This time the sensor checks left and right at a 115 Degree angle to extend its field of view.
- ➔ If the sensor does not detect any obstacle it assumes that it is safe to pass. This provides extra assistance to the passengers inside who cannot steer or brake.
- ➔ However, if there is an obstacle, the vehicle rotates itself to a 5-15 degree angle and checks if there are any obstacles in the way.
- ➔ The system constantly checks itself if there is an obstacle and stops and rotates when it needs to.
- ➔ When the motors are turned on, the LEDs attached to it are on also. This provides some extra clearance and awareness to pedestrians nearby, to know which motors are on and which ones aren't.
- ➔ The program loops to check if there are no obstacles.

6.5 Mechanical Assembly

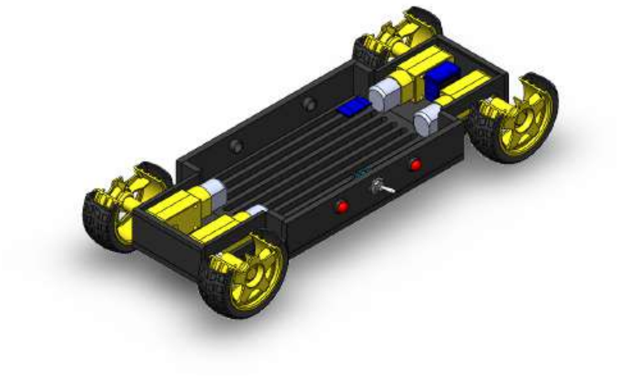
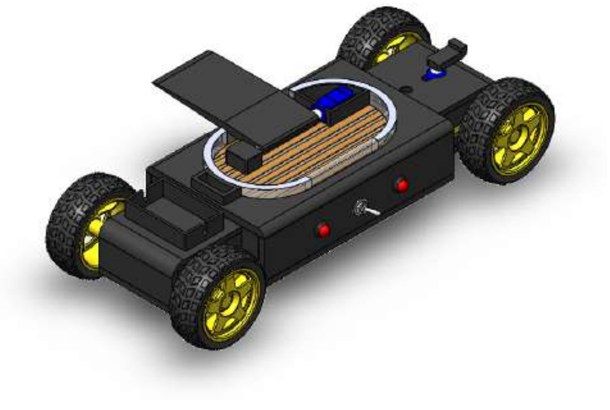


This is how the ultrasonic sensor will be positioned to the servo motor via the structural support part so when the program is running the servo motor rotates left and right at a 115 degree angle, where the ultrasonic sensor rotates with it also.





This is where the retractable platform will be positioned with a servo motor. A section is cut from the wood board,covered by two housing parts, one that houses the servo motor and one that is the stabiliser. The structural supports and housing provide extra stabilisation for the platform when it rotates safely. At the start of the program, the retractable platform lowers at a 110 degree angle, waits for 10 seconds before rotating back to its original position.

4 Gearbox DC Motors are positioned at the base that are symmetrical. Both sides are connected to the motor housing sides that allow enough clearance between the motor and the wheel that is connected to each individual motor. The motors are independent of each other, which allows them to work by itself and provide further stability and rotational speed. When the program is running, all the motors apart from the servos work together to reverse and rotate when needed.

7. Production Planning

7.1. Material and Component Lists

Description	Material/Component	Size	Quantity	Supplier
Part A	Clear 5mm Acrylic	170 x 80 x 5	1	Miko Metals
Part B	White PLA	160 x 90 x 25	1	Sindoh Filament
Part C	Arduino Uno R3 + L293D 4-Channel Motor Driver Shield	69 x 53 x 25	1	Arduino Store
Part D	Ultrasonic HC-04 Sensor	45.2 x 20.6 x 1	1	Gleann Electronics
Part E	Black 5 mm Acrylic	60 x 10 x 5	1	Miko Metals
Part F	White PLA	62 x 66 x 5	1	Sindoh Filament
Part G1-4	Black 5mm Acrylic	33 x 15 x 5	4	Miko Metals
Part H1-4	Black 5mm Acrylic	58 x 29 x 5	4	Miko Metals
Part I	Wheels	75 x 75 x 35	4	Rapid Online
Part J	White PLA	98.5 x 50 x 5	1	Sindoh Filament
Part K	White PLA	170 x 33 x 5	1	Sindoh Filament
Part L1-2	Black 5mm Acrylic	66 x 62 x 5	2	Miko Metals
Part M	Black 5mm Acrylic	170 x 106 x 5	1	Miko Metals
Part N1-4	Gearbox DC Motor	65.4 x 22.5 x 20	4	Rapid Online
Part O	White PLA	170 x 106 x 5	1	Sindoh Filament
Part P	White PLA	66 x 62 x 5	1	Sindoh Filament
Part Q	White PLA	55 x 35 x 1 x 60	1	Sindoh Filament
Part R1-4	LED + Holder	4.5 x 5 x 5.5	4	Rapid Online
Part S	SPST Switch	50 x 3.5 x 15	1	Rapid Online
Part T	White PLA	15 x 28 x 3 x 116	1	Rapid Online
Part U	Clear 3mm Acrylic	8 x 84 x 3	1	Rapid Online
Part V	White PLA	170 x 33 x 5	1	Sindoh Filament
Part W1-2	Clear 5mm Acrylic	R40 x 110 x 5	2	Miko Metals

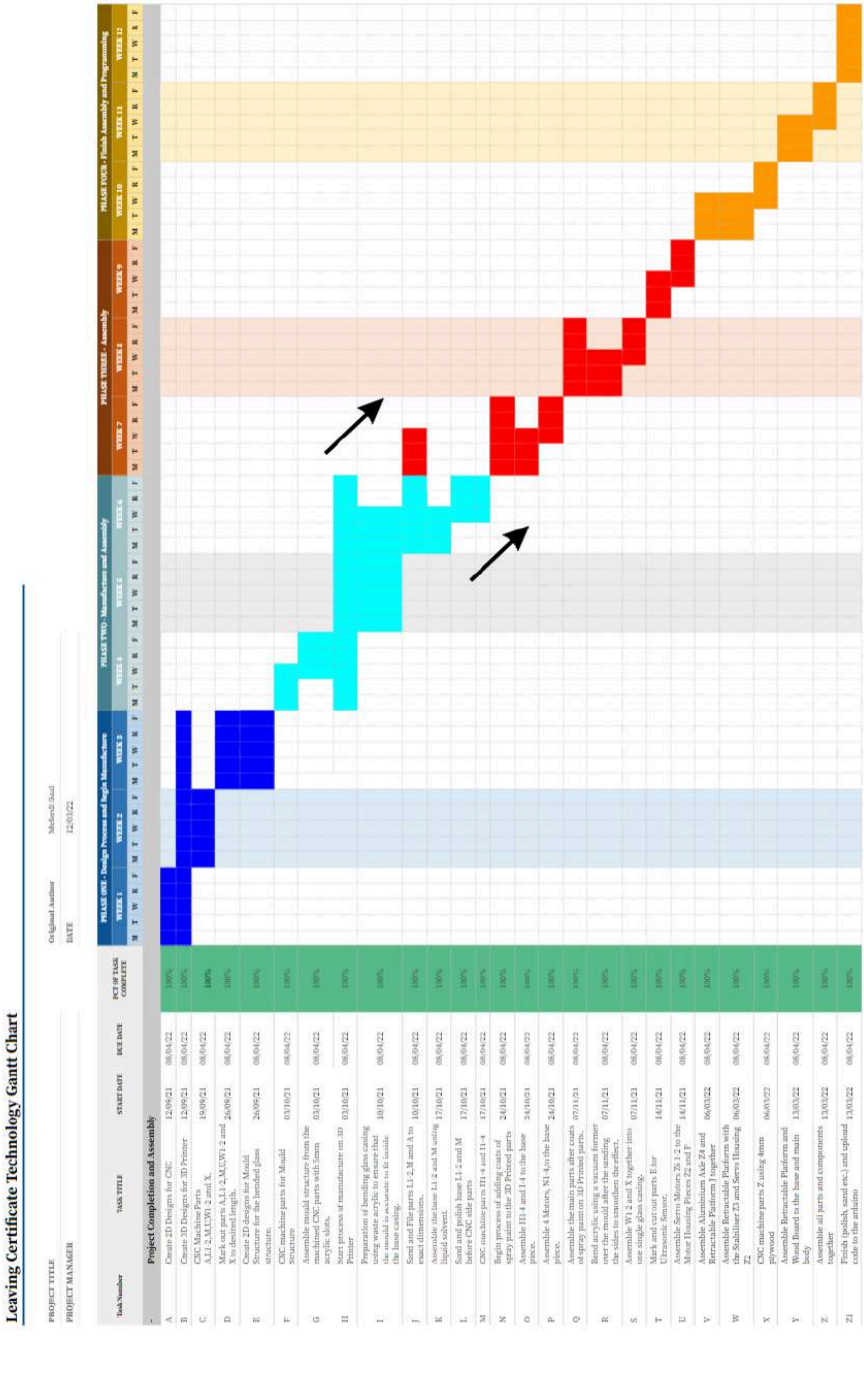
Part X	Clear 5mm Acrylic	110 x 60 x 5	1	Miko Metals
Part Y	White PLA	30 x 14.95 x 3 x 20	1	Sindoh Filament
Part Z	4mm Plywood	130 x 70 x 4	1	Miko Metals
Part Z2	White PLA	32 x 35 x 3 x 10	1	Sindoh Filament
Part Z3	White PLA	16 x 12 x 10.5	1	Sindoh Filament
Part Z4	Aluminium 3mm Axle	65 x D3	1	Miko Metals
Part Z51-2	Servo Motor Rotational Part	40 x 10 x 5	2	Rapid Online
Part Z61-2	Servo Motor	60 x 15 x 40	2	Rapid Online

7.2 Manufacture Work Breakout Structure (WBS)

Task	Description	Earliest Start Time (EST)	Length (Weeks)	Predecessor(s)
A	Create 2D designs for CNC	Week 1	1	N / A
B	Create 3D Designs for 3D Printer	Week 1	4	N / A
C	CNC machine parts A,L1-2,M,U,W1-2 and X.	Week 2	1	A
D	Mark out parts A,L1-2,M,U,W1-2 and X to desired length.	Week 3	1	C
E	Create 2D designs for Mould Structure for the bended glass structure.	Week 3	1	N / A
F	CNC machine parts for Mould Structure	Week 4	0.5	E
G	Assemble mould structure from the machined CNC parts with 5mm acrylic slots.	Week 4	0.5	F
H	Start process of manufacture on 3D Printer	Week 4	3	B
I	Preparation of bending glass casing using waste acrylic to ensure that the mould is accurate to fit inside the base casing.	Week 5	1.5	G
J	Sand and File parts L1-2,M and A to exact dimensions.	Week 5	1.5	D
K	Assemble the base L1-2 and M using liquid solvent.	Week 6	0.5	J
L	Sand and polish base L1-2 and M before CNC side parts	Week 6	0.5	K
M	CNC machine parts H1-4 and I1-4	Week 6	0.5	A
N	Begin process of adding coats of spray paint to the 3D Printed parts	Week 7	1	H

O	Assemble H1-4 and I-4 to the base piece.	Week 7	0.5	M
P	Assemble 4 Motors, N1-4,to the base piece.	Week 7	0.5	O
Q	Assemble the main parts after coats of spray paint on 3D Printed parts.	Week 8	1	N
R	Bend acrylic using a vacuum former over the mould after the sanding the sides to smoothen the effect.	Week 8	0.5	G
S	Assemble W1-2 and X together into one single glass casing.	Week 8	0.5	R
T	Mark and cut out parts E for Ultrasonic Sensor.	Week 9	0.5	N / A
U	Assemble Servo Motors Z6 1-2 to the Motor Housing Pieces Z2 and F	Week 9	0.5	N / A
V	Assemble Aluminium Axle Z4 and Retractable Platform J together	Week 10	0.5	N / A
W	Assemble Retractable Platform with the Stabiliser Z3 and Servo Housing Z2	Week 10	0.5	N / A
X	CNC machine parts Z using 4mm plywood	Week 10	0.5	A
Y	Assemble Retractable Platform and Wood Board to the base and main body	Week 11	0.5	X
Z	Assemble all parts and components together	Week 11	0.5	Y
Z1	Finish (polish, sand etc.) and upload code to the arduino	Week 12	0.5	Z

7.3 Gantt Chart with Critical Path Identified



7.4 Project Costing

Description	Material/Component	Size	Quantity	Supplier	Cost (EUR)
Part A, U, W1-2,X	Clear 5mm Acrylic	350x 300x 5	1	Miko Metals	5.67
Part G1-4,H1-4,L1-2, M	Black 5mm Acrylic	290 x 275 x 5	1	Miko Metals	4.83
Part C	Arduino Uno R3 + L293D 4-Channel Motor Driver Shield	69 x 53 x 25	2	Arduino Store	23.40 + 9.83 = 33.23
Part D	Ultrasonic HC-04 Sensor	45.2 x 20.6 x 1	1	Gleann Electronics	4.63
Part N1-4	Gearbox DC Motor	65.4 x 22.5 x 20	4	Rapid Online	7.73
Part Z4	Aluminium Rod	65 x D3	1	Miko Metals	0.84
Part Z61-2	Servo Motor	60 x 15 x 40	2	Rapid Online	8.65
Part S	SPST Switch	50 x 3.5 x 15	1	Rapid Online	1.06
Part R1-4	Red LED + 4.5 mm LED Holder	4.5 x 5 x 5.5	4	Rapid Online	3.58
Part Z	4mm Plywood	130 x 70 x 4	1	Miko Metals	3.27
Part --	Male to Female Jumper Cables (For sensor and servos)	-	1	Amazon	4.90
				Total	78.39

8. Project Realisation

8.1. Sequence of Manufacture

During the manufacture of this project I divided the work into a number of subsections as outlined below:

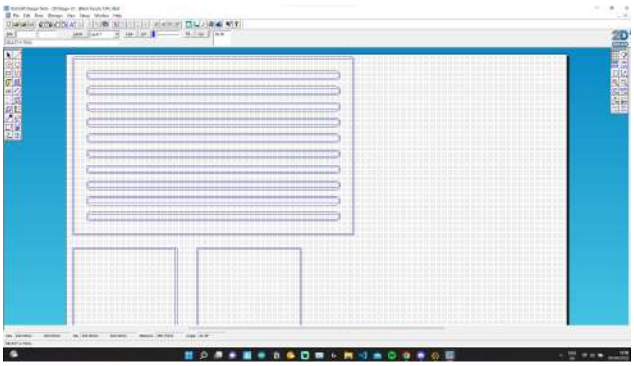
- ➔ **Manufacture of the Acrylic Base for the vehicle**
- ➔ **Manufacture of the Glass Casing**
- ➔ **Manufacture of the Main Body based off 3D Printing**
- ➔ **Assembly of the mechanisms**
- ➔ **Programming the Arduino Uno R3 and L293D Board**
- ➔ **Assembly and finishing the project to its expected standard.**

I will now outline with descriptions and with the aid of pictures that I took throughout my process on how each of these were carried out.

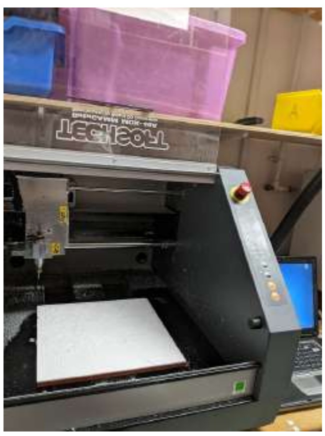
Sb Sct. 1. Manufacture of the Acrylic Base for the vehicle

This was carried out using the normal sequence of processes as outlined below:

a. **Creating design for each piece using Solidworks and 2D Design Software.**
For the designs I imported the design I made from Solidworks and imported the parts to SimLab Composer. In SimLab composer I then exported it to a Sketchup File. In Sketchup I then converted the file into a dxf. file using the built in camera and imported it to 2D Design as shown below in the following pictures.



b. **CNC Machining the Acrylic Base on the Roland Rotocamm MDX-40A CNC Machine.**
After finalising the designs for the CNC machine, I then prepared all the necessary safety requirements and procedures before starting the operation on the CNC Machine. After all the necessary procedures, the machine started cutting out the CNC designs from 2D Design software.



c. **Glueing and Finishing the Acrylic Base using liquid solvent and sandpaper.**
After the pieces are cut from the CNC Machine, I glued the pieces together using liquid solvent first to maximise the strength of the base. After the parts glued together, I then started to sand the base starting off with P600 sandpaper before moving to P1200 to finish off before polishing.After the sanding process, I filed the edges using rough files to file any scratches / marks on the sides.

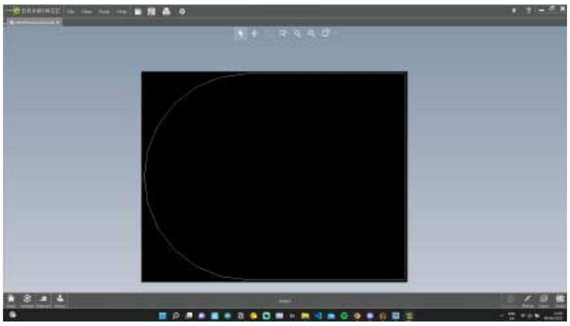
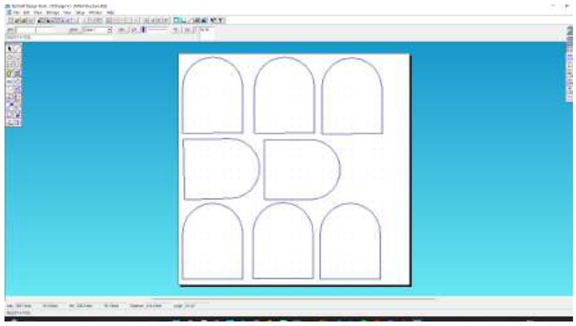



d. **Polishing the base using a polishing wheel and 10.8V cordless drill.**
After sanding and filing off the edges as shown in the previous step, I then started to polish the base using a polish wheel and a 10.8V cordless drill before the main assembly begins. The polishing process gives the base a better appearance and reduces any debris before the main assembly begins.


Sb Sct.2 2. Manufacture of the Glass Casing

This was carried out using the normal sequence of processes as outlined below:

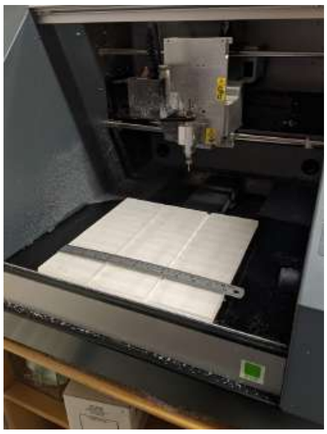
a. **Creating design for each piece using Solidworks and 2D Design Software.**
For the designs I imported the design I made from Solidworks and imported the parts to SimLab Composer. In SimLab composer I then exported it to a Sketchup File. In Sketchup I then converted the file into a dxf. file using the built in camera and imported it to 2D Design as shown below in the following pictures. Same procedure as before, but with a different drawing.

b. **CNC Machining the Mould Structure on the Roland Rotocamm MDX-40A CNC Machine.**

After finalising the designs from 2D Design, I then prepared all the necessary safety requirements and procedures before starting the operation on the CNC Machine. After all the necessary procedures, the machine started cutting out the CNC designs from 2D Design software.






c. **Glueing the Mould Pieces together with liquid solvent + Sanding**

After retrieving the pieces made by the CNC Machine, I then started to glue the pieces together using liquid solvent to strengthen the effect. I also separated the pieces using waste 5mm acrylic to ensure less waste is used and providing better structure and avoiding extra costs when the mould structure is ready to be used.After I assembled the mould, I then sanded off the the edges created by the CNC to minimise the sharp edges before using my acrylic pieces on the mould.

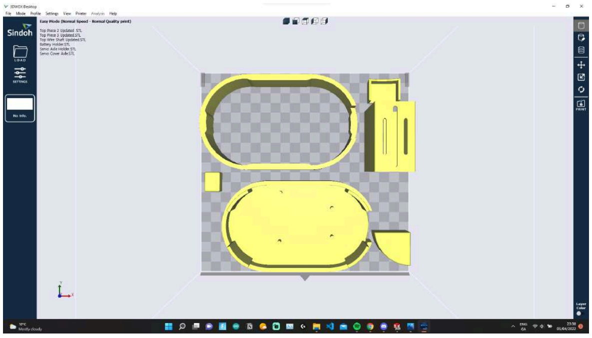
d. **Bending the acrylic piece onto the Mould**

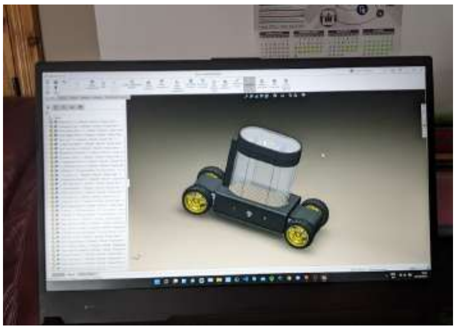
After finishing the mould structure, I turned on the vacuum former with all necessary safety procedures to ensure that the former is ready to go with its optimal temperature. I put in the acrylic at the same time and waited for approx. 5 -10 minutes to ensure that the acrylic is hot enough to bend. After it has heated up, I put the heated acrylic onto the mould structure quickly to ensure that it keeps its shape. I then put the mould into a sink and turned on cold water so the heated acrylic can be cooled quickly and maintain its shape much faster.

Sb Sct. 3. Manufacture of the Main Body based off 3D Printing

This was carried out using the normal sequence of processes as outlined below:

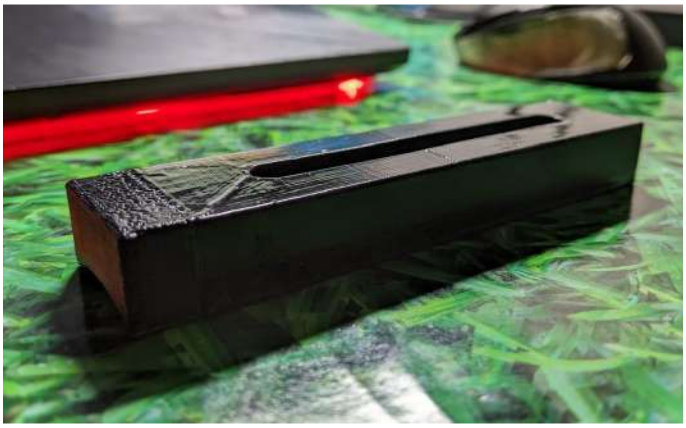
a. **Creating design for each piece using Solidworks and Sindoh 3DWOX Desktop**
   For the designs I made the parts from Solidworks and exported them into an STL File. I then imported the STL files to Sindoh's 3DWOX Software to position them on the bed to ensure better accuracy when the 3D printer is printing and to know the exact position.





b. **3D Printing the parts from SolidWorks**
   After completing the first step, I then imported all the necessary files to the Sindoh 3D Printer. With all the necessary information and procedures, the printer started to make the parts over time. After the parts were completed, I then started to dismantle them carefully and started to roughly assemble the parts to ensure that they are up to scale as produced by Solidworks in the software.

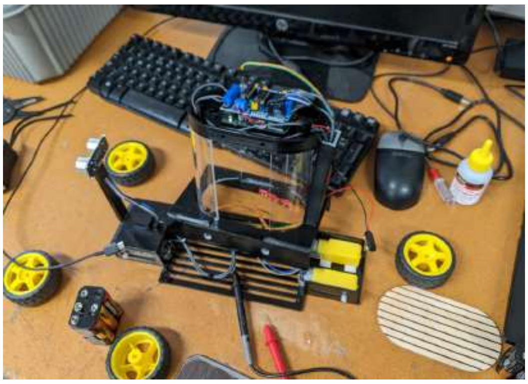
c. **Spray Painting the 3D Printed Parts**
After all the parts have been 3D printed fully, I then added coats of spray paint onto the parts to give it a nice finish. I allowed the paint to dry on the parts for over 24 hours to maximise its effectiveness and to improve its appearance when working on the parts. After the parts had dried, I then started to assemble the parts together.



Sb Sct. 3. Assembly of the mechanisms

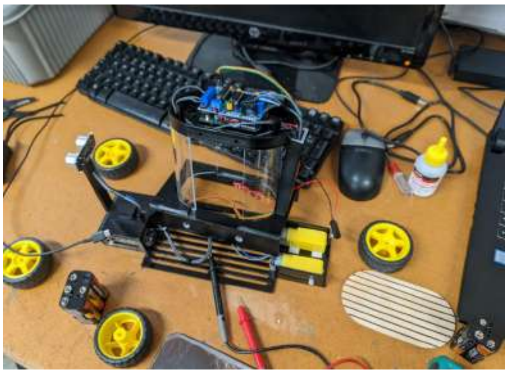
This was carried out using the normal sequence of processes as outlined below:

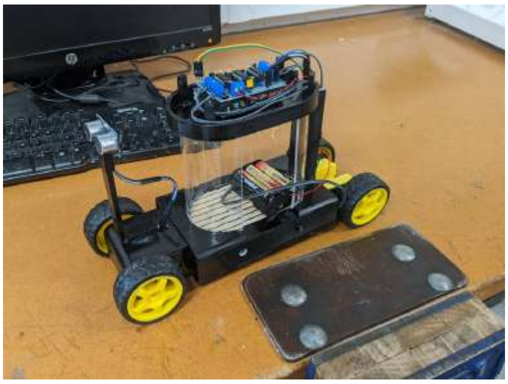
a. **Assembling 4 Gearbox DC Motors to the 4 sides on the base**
After finishing the manufacturing of the 3D Printed parts and Acrylic base, I then started to position the 4 gearbox DC motors on each side of the base to start the assembly of the base mechanism driving the motors.After the assembly I started to position the other mechanisms



b. Assembly of the Ultrasonic Sensor HC-04

After positioning the 4 gearbox motors to the base , I glued the servo motor onto the front motor housing with the holes as shown in the pictures. I then connected the sensor support part to the servo motor and positioned it straight so it will be easier to program due to its angled position.





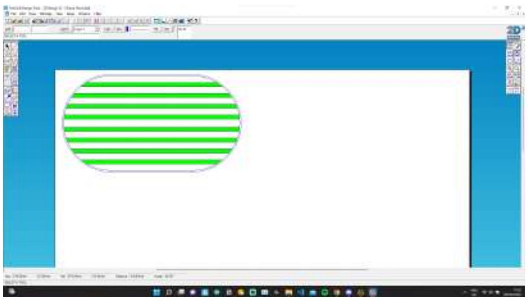
c. Assembly of the Retractable Mechanism

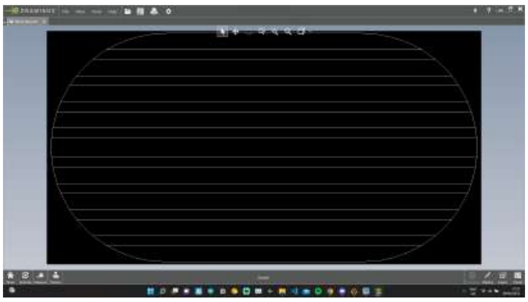
After the assembly of 2 mechanisms, the motors and the sensor, I started to assemble the retraction mechanism.

This was carried out using the normal sequence of processes as outlined below:

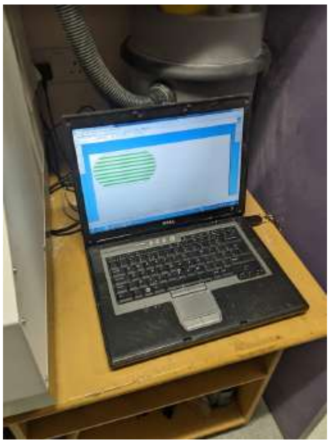
1) Creating design for each piece using Solidworks and 2D Design Software.

For the designs I imported the design I made from Solidworks and imported the parts to SimLab Composer. In SimLab composer I then exported it to a Sketchup File. In Sketchup I then converted the file into a dxf. file using the built in camera and imported it to 2D Design as shown below in the following pictures. Same procedure as before, but with a different drawing. For this one, I specifically added areas where the drill should go at a certain depth , which in this case is 1mm out of 4mm. This was done to give the wood some design aspect and creativity for the vehicle, giving it somewhat of an interior.

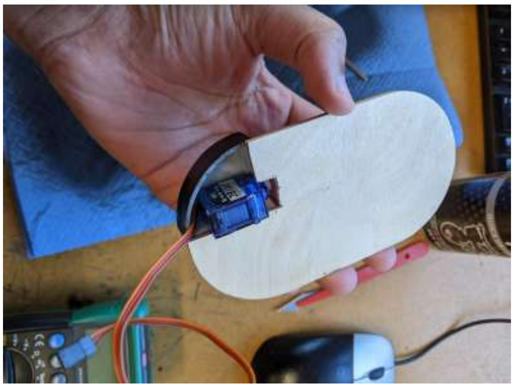


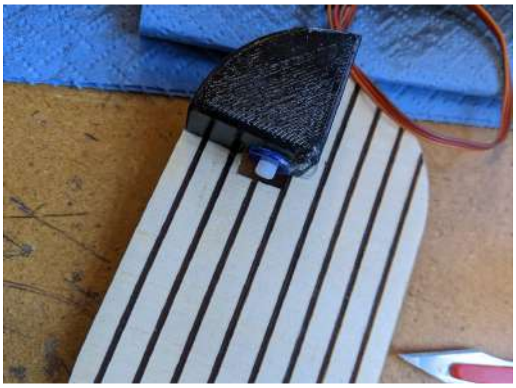


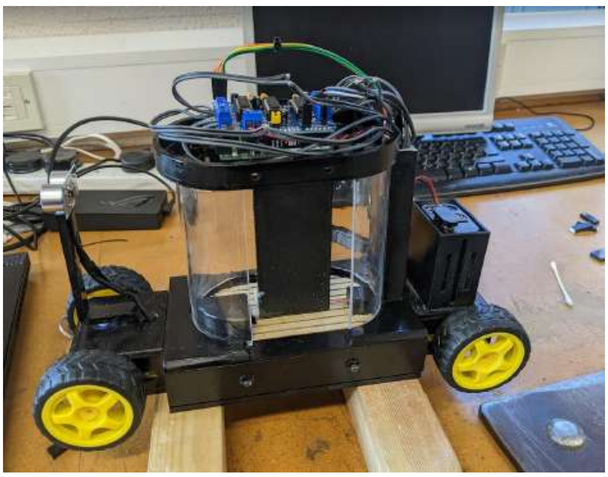
2) **CNC Machining the Wood Board on the Roland Rotocamm MDX-40A CNC Machine.**
After finalising the designs from 2D Design, I then prepared all the necessary safety requirements and procedures before starting the operation on the CNC Machine. After all the necessary procedures, the machine started cutting out the CNC designs from 2D Design software.



3) **Assembling the servo motor onto the housing and mechanism**
After the CNC Machine process, I then started to glue the servo motor housing and the wood board together using mitre glue to strengthen the effect. After the glue has dried I glued the servo motor to this position in the housing as shown in the pictures below. After assembling the servo motor I fitted an aluminium axle into the retractable platform and positioned the mechanism as shown below.







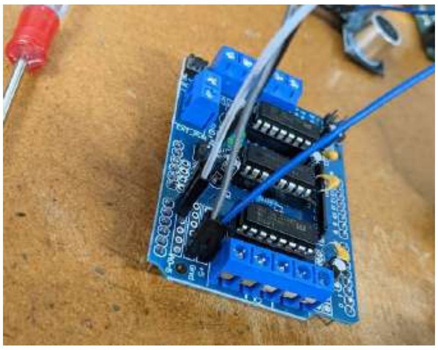
Sb Sct. 4. Programming + Assembly of the Arduino Uno R3 and L293D Board

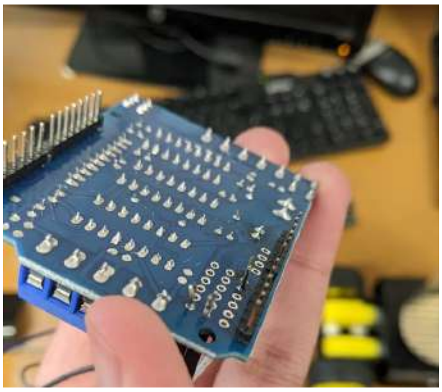
The control system for my project included the following:

- ➔ **Inputs**: SPST Switch and Ultrasonic HC-04 sensor
- ➔ **Process**: Arduino Uno R3 + L293D Motor Board Shield
- ➔ **Outputs**: 4x Gearbox DC motors, 2x servo motors and 4 LEDs

The following pictures show the process of the components being connected and assembled to the Arduino and L293D Motor Board.

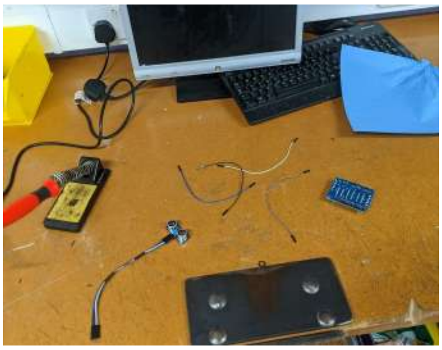
- ➔ The LEDs are connected with a 330Ω Ohm resistor since they are connected with a 9V Power supply that is powering up all the motors and the board itself.
- ➔ Soldering the resistor and the cable together

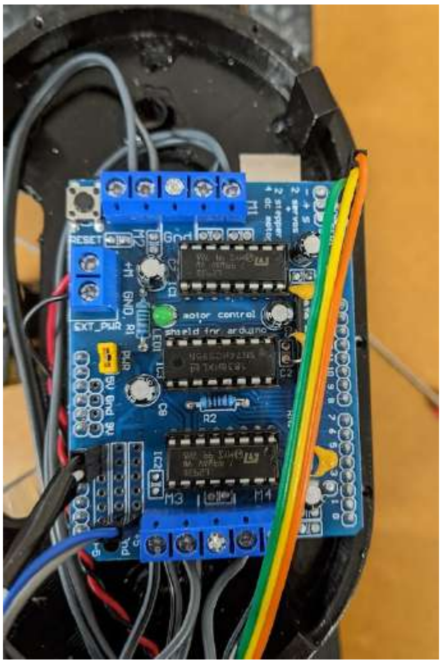




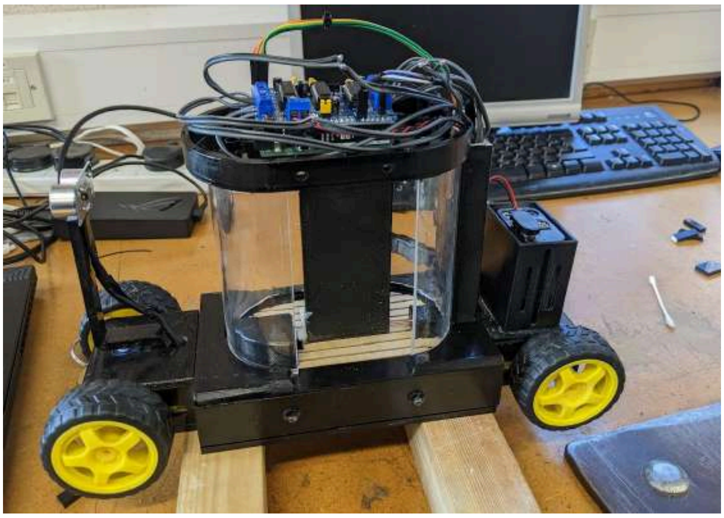
- ➔ Male to Female Jumper Cables soldered into these positions on the L293D Board
- ➔ These are soldered so they are connected to the board and the positions are for the ultrasonic sensor to function.

- ➔ Male to Female Jumper cables are connected to the HC-04 sensor using colour coded cables so it's easier to identify in case something is broken.
- ➔ The cables are connected to the corresponding cables that are connected and soldered to the motor shield so it can be programmed.





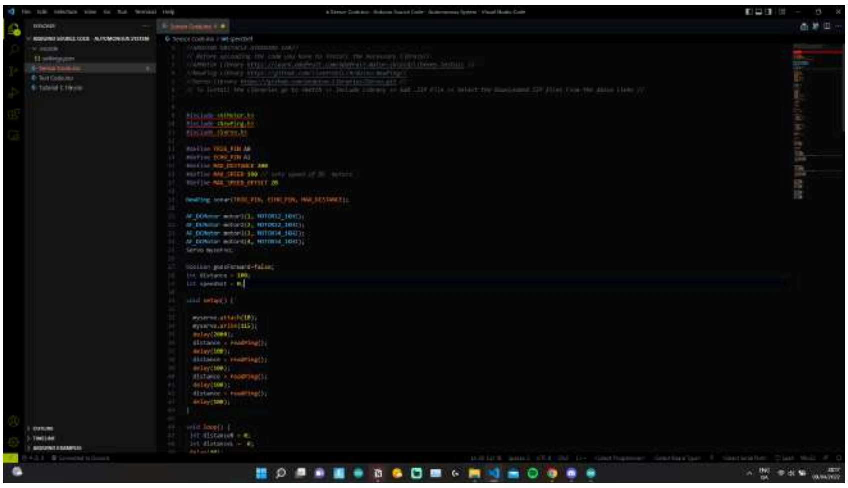
- ➔ The attached photos show the cables connected to the L293D Motor Shield and how the Arduino and the motor shield are connected and supported by the top casing.

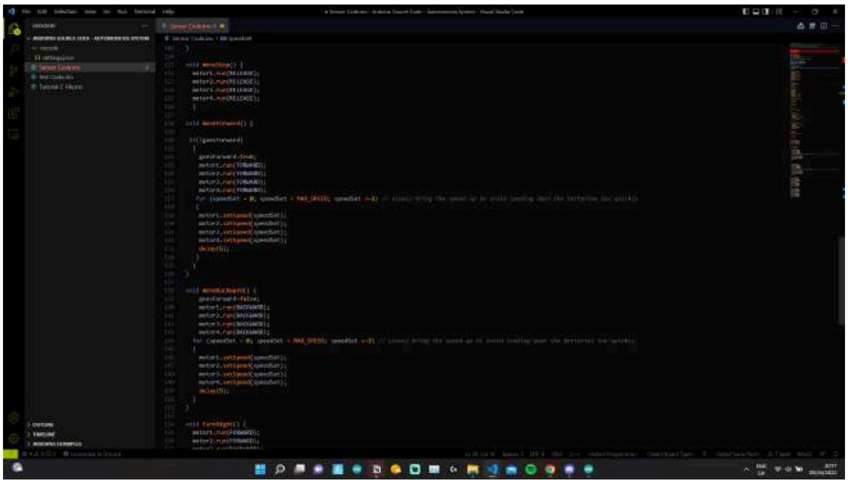


Programming the Arduino Uno

For my project I programmed the Arduino Uno R3 and the L293D Motor Shield using mainly Arduino's IDE software and Visual Studio Code (VSC).

```
//ARDUINO OBSTACLE AVOIDING CAR//
// Before uploading the code you have to install the necessary library//
//AFMotor Library https://learn.adafruit.com/adafruit-motor-shield/library-install //
//NewPing Library https://github.com/livetronic/Arduino-NewPing//
//Servo Library https://github.com/arduino-libraries/Servo.git //
// To Install the libraries go to sketch >> Include Library >> Add .ZIP File >> Select the Downloaded ZIP files From the Above links //


#include <AFMotor.h>
#include <NewPing.h>
#include <Servo.h>

#define TRIG_PIN A0
#define ECHO_PIN A1
#define MAX_DISTANCE 200
#define MAX_SPEED 190 // sets speed of DC  motors
#define MAX_SPEED_OFFSET 20

NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE);

AF_DCMotor motor1(1, MOTOR12_1KHZ);
AF_DCMotor motor2(2, MOTOR12_1KHZ);
AF_DCMotor motor3(3, MOTOR34_1KHZ);
AF_DCMotor motor4(4, MOTOR34_1KHZ);
Servo myservo;


boolean goesForward=false;
int distance = 100;
int speedSet = 0;

void setup() {
  myservo.attach(9);
  myservo.write(110);
  delay(10000);
  myservo.write(-95);
  delay(10000);
  myservo.attach(10);
  myservo.write(115);
  delay(2000);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);

}

void loop() {
 int distanceR = 0;
 int distanceL =  0;
 delay(40);

 if(distance<=15)
 {
  moveStop();
  delay(100);
  moveBackward();
  delay(300);
  moveStop();
  delay(200);
  distanceR = lookRight();
  delay(200);
  distanceL = lookLeft();
  delay(200);


  if(distanceR>=distanceL)
  {
    turnRight();
    moveStop();
  }else
  {
    turnLeft();
    moveStop();
  }
 }else
 {
  moveForward();
 }
 distance = readPing();
}

int lookRight()
{
    myservo.write(50);
    delay(500);
    int distance = readPing();
    delay(100);
    myservo.write(115);
    return distance;
}

int lookLeft()
{
    myservo.write(170);
    delay(500);
    int distance = readPing();
    delay(100);
    myservo.write(115);
    return distance;
    delay(100);
}


int readPing() {
  delay(70);
  int cm = sonar.ping_cm();
  if(cm==0)
  {
    cm = 250;
  }
  return cm;
}

void moveStop() {
  motor1.run(RELEASE);
  motor2.run(RELEASE);
  motor3.run(RELEASE);
  motor4.run(RELEASE);
  }

void moveForward() {

 if(!goesForward)
  {
    goesForward=true;
    motor1.run(FORWARD);
    motor2.run(FORWARD);
    motor3.run(FORWARD);
    motor4.run(FORWARD);
   for (speedSet = 0; speedSet < MAX_SPEED; speedSet +=2) // slowly bring the speed up to avoid loading down the batteries too quickly
   {
    motor1.setSpeed(speedSet);
    motor2.setSpeed(speedSet);
    motor3.setSpeed(speedSet);
    motor4.setSpeed(speedSet);
    delay(5);
   }
  }
}
```





```
void moveBackward() {
    goesForward=false;
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
    motor3.run(BACKWARD);
    motor4.run(BACKWARD);
  for (speedSet = 0; speedSet < MAX_SPEED; speedSet +=2) // slowly bring the speed up to avoid loading down the batteries too quickly
  {
    motor1.setSpeed(speedSet);
    motor2.setSpeed(speedSet);
    motor3.setSpeed(speedSet);
    motor4.setSpeed(speedSet);
    delay(5);
  }
}

void turnRight() {
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(BACKWARD);
  motor4.run(BACKWARD);
  delay(500);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}

void turnLeft() {
  motor1.run(BACKWARD);
  motor2.run(BACKWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
  delay(500);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}
```

Program Explanation

```
//ARDUINO OBSTACLE AVOIDING CAR//
// Before uploading the code you have to install the necessary library//
//AFMotor Library https://learn.adafruit.com/adafruit-motor-shield/library-install //
//NewPing Library https://github.com/livetronic/Arduino-NewPing//
//Servo Library https://github.com/arduino-libraries/Servo.git //
// To Install the libraries go to sketch >> Include Library >> Add .ZIP File >> Select the Downloaded ZIP files From the Above links //


#include <AFMotor.h>
#include <NewPing.h>
#include <Servo.h>

#define TRIG_PIN A0
#define ECHO_PIN A1
#define MAX_DISTANCE 200
#define MAX_SPEED 190 // sets speed of DC  motors
#define MAX_SPEED_OFFSET 20

NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE);

AF_DCMotor motor1(1, MOTOR12_1KHZ);
AF_DCMotor motor2(2, MOTOR12_1KHZ);
AF_DCMotor motor3(3, MOTOR34_1KHZ);
AF_DCMotor motor4(4, MOTOR34_1KHZ);
Servo myservo;
```

The first section of this code defines all the inputs and outputs on the arduino and also tells the arduino to use a library for the Servo, Motors, and the Ultrasonic Sensor.

```
boolean goesForward=false;
int distance = 100;
int speedSet = 0;

void setup() {
  myservo.attach(9);
  myservo.write(110);
  delay(10000);
  myservo.write(-95);
  delay(10000);
  myservo.attach(10);
  myservo.write(115);
  delay(2000);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);
  distance = readPing();
  delay(100);

}

void loop() {
 int distanceR = 0;
 int distanceL =  0;
 delay(40);

 if(distance<=15)
 {
  moveStop();
  delay(100);
  moveBackward();
  delay(300);
  moveStop();
  delay(200);
  distanceR = lookRight();
  delay(200);
  distanceL = lookLeft();
  delay(200);
```

The second section of the code first rotates the platform 90 degrees down, waits for 10 seconds, rotates back up to its original position, waits for 10 seconds before rotating the sensor at 0 degrees.

The sensor then turns on and detects if there is any movement in order to activate the program. After it detects an object, it moves forward.

When it detects an obstacle or a fast moving object, the system stops and the sensor rotates at 110 degrees left and right to check if there is any obstacle in its field of view.

```
  if(distanceR>=distanceL)
  {
    turnRight();
    moveStop();
  }else
  {
    turnLeft();
    moveStop();
  }
 }else
 {
  moveForward();
 }
 distance = readPing();
}

int lookRight()
{
    myservo.write(50);
    delay(500);
    int distance = readPing();
    delay(100);
    myservo.write(115);
    return distance;
}

int lookLeft()
{
    myservo.write(170);
    delay(500);
    int distance = readPing();
    delay(100);
    myservo.write(115);
    return distance;
    delay(100);
}
```

The third section of the code defines what distance the sensor should look at, with some delay and time in between to allow extra time and accuracy for the sensor to pick up.

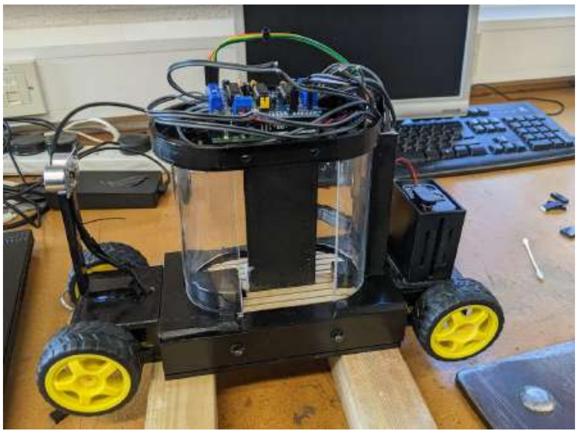
The last section (the two pictures below) defines the direction of the motors and is on a loop, activated when the sensor does or does not detect an obstacle.

```
int readPing() {
  delay(70);
  int cm = sonar.ping_cm();
  if(cm==0)
  {
    cm = 250;
  }
  return cm;
}

void moveStop() {
  motor1.run(RELEASE);
  motor2.run(RELEASE);
  motor3.run(RELEASE);
  motor4.run(RELEASE);
  }

void moveForward() {

 if(!goesForward)
  {
    goesForward=true;
    motor1.run(FORWARD);
    motor2.run(FORWARD);
    motor3.run(FORWARD);
    motor4.run(FORWARD);
   for (speedSet = 0; speedSet < MAX_SPEED; speedSet +=2) // slowly bring the speed up to avoid loading down the batteries too quickly
   {
    motor1.setSpeed(speedSet);
    motor2.setSpeed(speedSet);
    motor3.setSpeed(speedSet);
    motor4.setSpeed(speedSet);
    delay(5);
   }
  }
}
```

```
void moveBackward() {
    goesForward=false;
    motor1.run(BACKWARD);
    motor2.run(BACKWARD);
    motor3.run(BACKWARD);
    motor4.run(BACKWARD);
  for (speedSet = 0; speedSet < MAX_SPEED; speedSet +=2) // slowly bring the speed up to avoid loading down the batteries too quickly
  {
    motor1.setSpeed(speedSet);
    motor2.setSpeed(speedSet);
    motor3.setSpeed(speedSet);
    motor4.setSpeed(speedSet);
    delay(5);
  }
}

void turnRight() {
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(BACKWARD);
  motor4.run(BACKWARD);
  delay(500);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}

void turnLeft() {
  motor1.run(BACKWARD);
  motor2.run(BACKWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
  delay(500);
  motor1.run(FORWARD);
  motor2.run(FORWARD);
  motor3.run(FORWARD);
  motor4.run(FORWARD);
}
```

Sb Sct. 5. Assembly and finishing the project to its expected standard

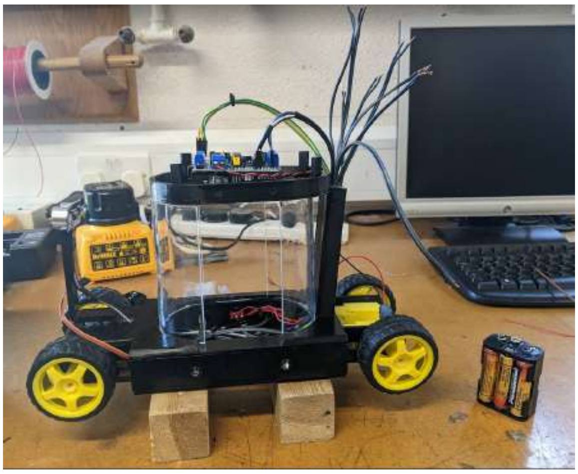
After I have completed all the subsections I outlined above I assembled and finished the project to its expected standard I estimated since designing and simulating the project.



This is an image of me testing the project to make sure that all mechanisms are functional and the wheels are going in the right direction.

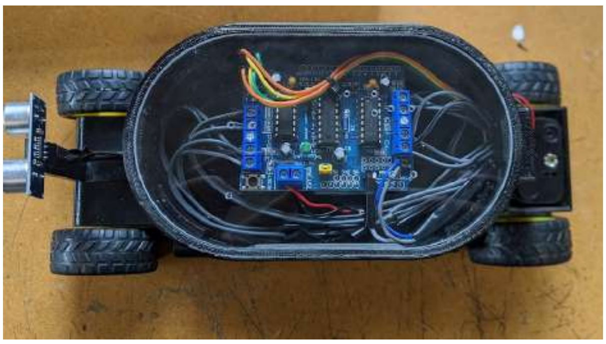
Wood blocks were added in place to stabilise the place and to avoid collision and pressure on the front and back which had the most load on the vehicle.

This is an image of me disassembling the middle piece and fixing the wiring in the project. The space allows me to reconnect and disconnect the wires easily without any issues when working with different components and it is easily replaceable if something was damaged.



This is an image of me disassembling the cables connected to the L293 Motor Driver Shield and brading the inside and fixing the cable management to ensure that there is no short circuit caused by the wires due to the vehicle using a 9V power supply.

The image on the left shows before I fixed the cables and the one below shows after I fixed all the cable management so it is much easier to work with in the future.



9. Testing, Evaluation and Critical Reflection

9.1. Testing against Chosen Brief and Evaluation of Final Artefact

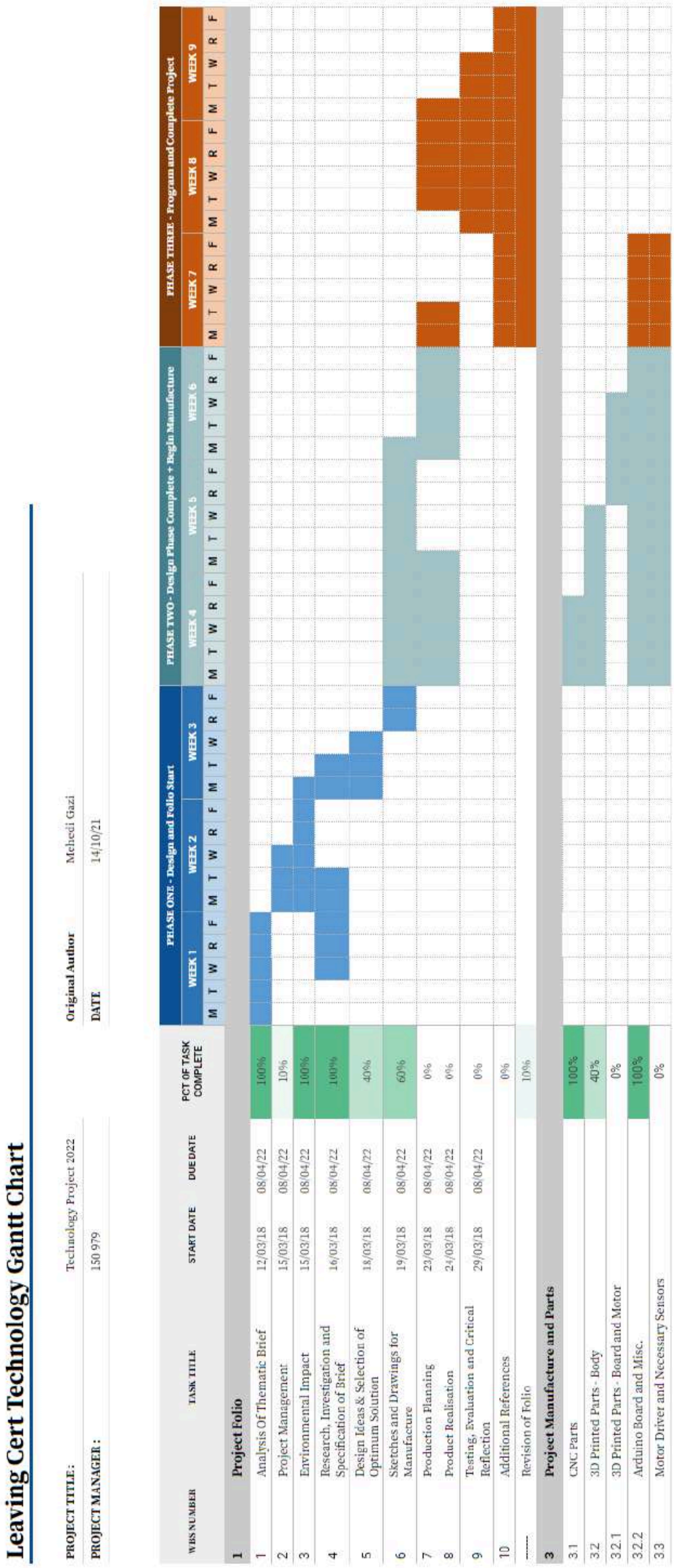
The attached table below outlines my earlier final brief and related specification from subsection 4.3 'Statement Outlining Final Brief and Related Specifications'. For this section, this is an extension of the initial thematic brief. The column beside the first column shown below outlines my evaluation of how well I achieved each specification that I set out.

Final Brief and Related Specifications	My Evaluation
I am going to design an autonomous vehicle known as 'Campus Shuttle' that assists users to use public transport and rely less on additional human assistance. This complies with the thematic brief since it has an electro-mechanical element and can improve the life of a user with limited ability.	I have designed and made an autonomous vehicle that is based off of the 'Campus Shuttle' that assists users to use public transport. I also added an electro-mechanical element that improves the life of a user with limited ability.
I will base my designs on the existing design(s) shown below that I found in my research	I have based my design on the designs that I found in section 4.1 'Analysis of Existing Solutions'
The main materials used for the structure of my project will be: ➔ PLA Plastic in Black used for 3D Printing ➔ Transparent Acrylic used for the glass casing	The main materials that I have manufactured for the project are 5mm black acrylic and 3D printed components.
I will be using the following inputs and outputs with the Arduino Uno Board: ➔ Inputs: Standard LDR / other sensors and microswitch with (Rapid Code: 562023) ➔ Outputs: Servo motor (Rapid Code 499395) and standard LEDs and Gearbox DC Motors	I have used an Arduino Uno R3 board with the following inputs and outputs. ➔ Inputs: Ultrasonic HC-04 Sensor and SPST Switch ➔ Outputs: 2x Servo Motors, 4x Gearbox DC Motors and 4x LEDs
The electro-mechanical element of my design will be a mechanism based on a combination of DC Motors with a servo motor controlling the platform	This was the electro-mechanical element of the project and design.
I will include the following safety considerations: ➔ No sharp edges ➔ No dangerous moving parts ➔ No toxic material ➔ No electrical hazard	All of these safety considerations were followed throughout my project.

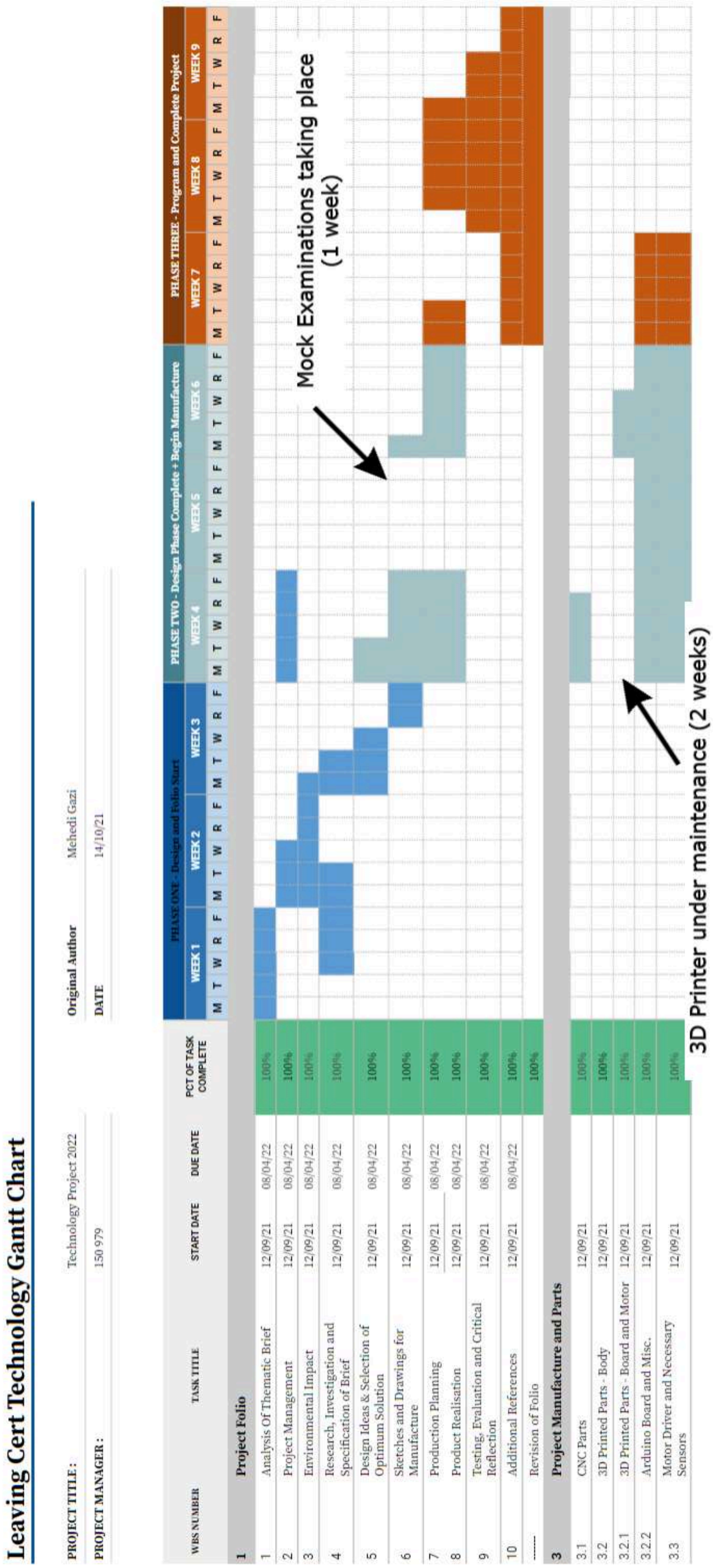
I intend to complete the manufacture of my project by Friday 18th March, allowing 3 weeks for testing and commissioning.	I did not complete the project by this time due to mock examinations taking place a few weeks during manufacture and the 3D printer undergoing maintenance which caused some delay on my project.
The budget for this project will be €80 maximum.	After calculating the materials and components I used, I was within the budget with some money to spare.

9.2 Comparison of Planned Schedules and Actual Schedules

Planned Schedule Gantt Chart:



Actual Schedule Gantt Chart:



Differences Between Planned Schedule Gantt Chart and Actual Schedule Gantt Chart

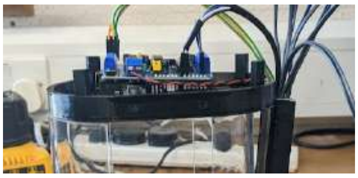
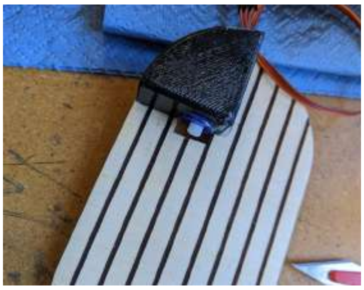
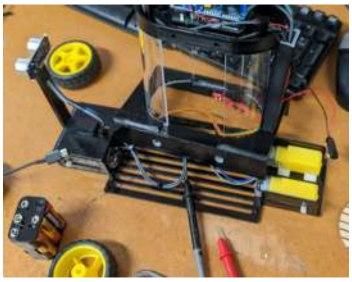
There are a number of reasons as to why my actual Gantt chart is different to my scheduled Gantt Chart. The explanation of each difference is outlined below.

Difference	Explanation
Design Process and Research took longer than originally planned.	The research and design process took much longer than planned due to the amount of components I was using and the way of working around with a new board I had never used before. More time also took onto the mechanism since I was using 3 different mechanisms that can fit the thematic brief.
3D Printing took much more time than originally planned.	The 3D printing process took more time than originally planned due to the 3D printer undergoing maintenance and other students using it as part of their project.
Section 6, 7, 8 taking more time than originally planned	Section 6,7, and 8 took more time than originally planned due to the mock examinations taking place in between, which had to take more time on that while focusing on completing the project.

9.3 Suggested Modifications with Justifications

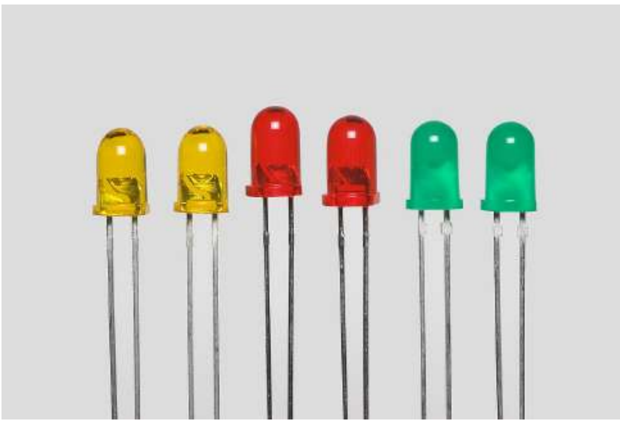
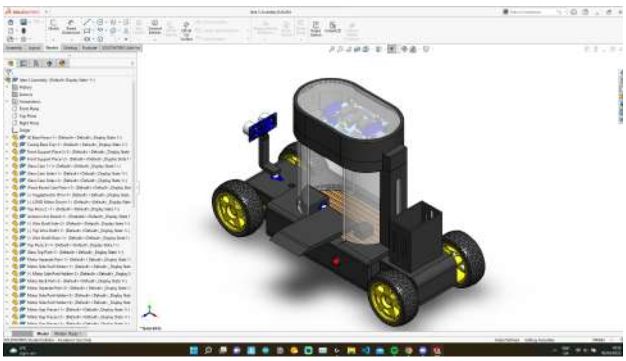
Modifications carried out throughout the course of the project

Throughout the manufacturing process of my project the design was altered slightly, and other modifications were added to improve the functionality of my project and to further back up the thematic brief. The modifications that were carried out were as follows in the following table.

Modifications	Explanation
 **(Before)**  **(After)**	When the project was near to completion, I noticed some eros that needed to be fixed to the board. My original base had short mounting holes for the Arduino, and the base was too short to fit all the cables, which may cause a collision with the other cables, especially the soldered cables for the ultrasonic sensor and the servo motor cables. With my new modification in fixing the design in solidworks, I made the height bigger and the mounting holes longer to make the board stable and allow more space for easier cable management.
	When CNC Machining the wood board, I noticed an error that could cause damage to my project which was the servo motor. For this, I cut a small section in where the servo was positioned with the housing, so the servo motor is accurately placed and would not cause collision with the axle involved due to the rotation load it had while rotating the platform to a flat position and rotating back up to an upright position.
(Before) **(After)**  	Initially in my project I was trying out a 2 motor-drive system, but I noticed major errors when controlling the project. The first major error was the stability of the motors, since the axles connected to it were weak and can cause the vehicle to collapse. The second major flaw was the rotational speed, since with a 2 motor drive system the vehicle will take much longer to rotate itself. For that reason I moved to a 4 motor drive system which was much easier to work around with and with various support on the Arduino IDE software and Visual Studio Code.

Modifications I would carry out if I had more time:

If I was able to do this project again with no time limitation, I would like to make the following changes:

Modifications	Explanation
	If I had more time I would’ve added an extra bluetooth module to the Arduino Uno Board. This would allow the vehicle to be remotely controlled, which can be easier for the user since it does require a physical steering wheel and the phone’s integrated gyroscope can show what direction the user intends to go.
	I would’ve added more LEDs to the overall project. If I had more time, I would’ve added LEDs on the top of the interior to allow some lighting at night, LEDs in the front and back of the vehicle to act as headlights when it is night time or when conditions are not optimal.
	I would’ve taken more time on the design process, making it more advanced and spending more time on how to make the vehicle more smarter, possibly adding AI-based computing and voice control to make it much better for someone to use with limited ability. My project is advanced at my level, but I’d like to take more time to change someone’s life if I had more time working towards the mechanism and design sector.

9.4 Critical Reflection on Entire Process

Design Process:

For my project, this was probably the most difficult and challenging journey I had to endure in difficult times where time management is key. My Junior Certificate project was much more advanced at that time in 3rd Year (winning Project of the Year using different techniques and a combination of 3D Printing and Sketchup work), but I wanted to take it to a whole another level when entering the Leaving Certificate, using advanced software and techniques I've never used before. People usually go out basic in terms of getting a good project, but there are always people that want to push that boundary, which are people like me to try out new software and equipment that can allow better facilities when it comes to my design process. I took a different approach compared to the rest of my class, since everyone used SketchUp for their project, while I was the only one going with a different path using SolidWorks, which is much more advanced than usual CAD software. I found SolidWorks to be much easier than SketchUp, since I was using it from 3rd Year and gained a lot of experience from my other subject, Design and Communication Graphics, which allowed me to think differently and critically. SolidWorks allowed me to simulate and make my project much more advanced, allowing it to make the design much better in terms of looks. I did have some problems along the way, but the software itself allowed me to to think differently and think of solutions without needing to rely on SketchUp which is overall very basic and has limited features in the software itself. Dimensions and other features were very easy to change due to the built in assembly feature, which automatically changes and locks which is much easier than changing every time in SketchUp. Overall I really enjoyed this section and I found this sector to be a crucial factor in my project.

Project Management:

During the process of doing this project, my proper project management was absolutely crucial towards its completion. During the Leaving Certificate, we all have other assignments and other subjects to focus on while having limited time which is key in being successful in the examinations and other areas. Even though we were given an earlier deadline to complete the project, compared to my other subject assignment Design and Communication Graphics, I found myself to work in a different dimension, under constant load and pressure that did not allow any form of procrastination. I definitely believe that without proper time management, my project may not have been completed due to the advancements in the functionality of my components and the sectors I was working with. I've seen many people not completing their project in time over taking Technology in the past 6 years, and it definitely became a part of me to finish the assignment in the shortest time possible and to make it presentable and high quality standard that someone expects from an examination or any objective. Not finishing in time and any error was one of my biggest fears over the course of the project. Compared to the design process, there is a high level of intricacy and precision in production planning. I found that using gantt charts and other sorts of techniques with small deadlines was very useful to keep me up to date with other sectors and can help me complete the project in time with extra time to work around with. I managed to stay close to my timeframes even with the delays that occurred during the course of my project and I had managed to complete the project in time with enough time to work with the other sectors such as the folio and fixing minor areas inside my project such as cable management.

Manufacturing:

My manufacturing process began at the beginning of December. I started at the same time as most people in my class due to my carefully planned out gantt chart and planning process which outlined what objectives I had to complete. However, the 3D printer was undergoing maintenance and I was a bit behind in terms of getting all the parts ready. However, I had a big advantage on going with a 60% 3D Printing and 30% acrylic technique since I do not have to use a lot of tools when assembling the project and it allowed me to assemble and fix everything much faster that doing other processes such as sanding and polishing which is much more time consuming. The 3D parts were very beneficial since it allowed me to also reflect on my design process, to see if everything was up to scale and I can see if the external parts fit correctly inside the project as planned in my design. Due to the early start, there were not many queues for the CNC machine and the critical planning allowed me to work mostly from the 3D printer, since the majority of my class used mostly acrylic in their project. My only error was that some parts did not come up to scale as expected, which led some parts to be bent and not perpendicular to the other pieces. The super glue also caused an issue visually, since it left some marks and scratches on the coating of the spray paint. Overall I found the manufacturing process to be quite enjoyable, since it was easier to manage and there were less processes involved physically rather than the design process itself.

Programming:

The programming sector was probably the most challenging sector for me, since before starting the project, I wanted to pursue a different path in terms of programming after doing 3D Modelling for some time from CAD software such as Blender and Cinema4D. In the future I would like to pursue computer science in either Queen's University Belfast or in Trinity College Dublin to advance further in the field of engineering and computing, using methods I've never touched my hands on. Before coding, I tried out some python programming courses and started to use Visual Studio Code, which is really user friendly and allows beginners like myself to work on and understand the basics of programming. Over the course of my project, I learned how C++ works and how it can be used to direct various software commands. My biggest challenge was the programming of the ultrasonic sensor and inserting code at the start of the project to rotate the retractable platform up and down without breaking the whole script. Overall I found this sector to be the most interesting and challenging in the course of my project, since it requires critical thinking and different methods in order to compute something basic.

Overall Conclusion:

➔ Design Process and Research is absolutely crucial before starting a project you have never encountered before and it will make your life much easier before manufacturing it.
➔ It is absolutely essential to allow some weeks before the deadline to ensure that everything in the project is up to your expectations and there is a gap to fix any errors which may cause any future errors and bugs in the system and software.
➔ Projects like these take a lot of time to plan in difficult times and it takes a lot of time and dedication in order to make the project you think of. It is absolutely essential to work hard all the way and avoid procrastination in such difficult times when there is an ongoing pandemic, and other projects and assignments you need to focus on over the Leaving Certificate.
➔ Not everything will go as planned and it is important that you realise when something isn't what you expected it to be and you need to think critically to make all the necessary changes.

10. Additional References / Footnotes

Throughout the course of the project folio I used a number of websites for conducting my research and other sectors. All of the websites that I have not directly mentioned for each picture and listed below in the following table.

Website References

State Examinations Commission (SEC)	Rapid Online
Google Photos	Sindoh Filament
New York Times (NYT)	YouTube
Arduino Forum	Parentology
Illinois.edu	Techcrunch
Wired	The Verge
assistant.google.com	Yanko Design
Irish Electronics	Wiktionary
Indiamart	Amazon.co.uk
Shutterstocks	iStockPhoto
Google	Gleann Electronics

*All project designs were made by myself, however there are some external files, which are from GrabCAD. Everything else, including the research, the folio and the design overall was conducted by me under the supervision of my teacher. If files are required to see the design and code, please contact the school or my teacher if required.

Throughout the course of my project, I would like to thank all of the people who helped me throughout the course of my project, including various teachers, the school community, school resources and the wider community as well as the named sources above for my intensive research for my proposed design and project.
Finally, thank you for taking the time to read my portfolio based on my project!