EM106 Model AGV Project

Academic Year 2022/2023

Team Report

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Introduction (context, objectives)

Our AGV (Automated Guided Vehicle) was co-produced by the respective members: Aleksander Lanecki, Zygimantas Gricius, Alfie Antony and Anthony Clarke. Each of the following members worked on a crucial characteristic to design a fully fledged autonomous vehicle. Aleksander Lanecki moulded the Driving mechanism. The driving mechanism's role is to power the vehicle. Zygimantas Gricius was at the fore when it came to the Chassis and Component Layout. He provided the blueprints to assemble the car. Alfie Antony authorised the Steering Mechanism which helps the car to turn. Anthony Clarke was in charge of the Teamwork and Coordination aspect. He set up meetings and organised the team.

In this report, we will give a brief introduction to our AGV. Next, we will display our approach to the aspects of the mechanical design (steering,drive and chassis). We will then showcase the tests we ran in order to develop our software for this vehicle. We will digress onto how we were managed as a team and the issues faced along the way. Finally, we will conclude with our learning experience and references.

Background Motivation: Our team's background motivation for this project was that it was our first time working as a team to craft such a model. From this, our attitude towards the AGV remained high-spirited and resilient. All members felt a sense of excitement when they knew how valuable this project would be for their careers as engineers going forward. Overall, this initiated our plans of building the AGV.

Context: Our team's understanding of the context of the model AGV design project is that it is there to challenge the students' theory from the different components, labs and lectures. Here, they apply this in a practical sense by using all the fundamentals of engineering disciplines: mechanical, electronic and computer based technology to communicate and appreciate our ideas. We believe that the AGV is here to build our experiences as an engineer in order to mould our expectations in working as a team.

Objectives: As a team, we had a plethora of objectives we wanted to fulfil in relation to this project. These were the following:

All members must follow the team contract: Before even building the AGV we decided to build our relationship as a team in order to create a strong bond. The results of this have proven to be tremendous as our team comes to a compromise whereby every member's voices are heard.

All members must complete the role they were assigned: We believe that each team member should live up to their expectations when it comes to communicating as a team. Therefore, we know that it is essential that each team member does their part to complete this project.

The team must create an AGV that meets all of the requirements: The team must make sure that they have used the information obtained from previous labs, utilise all the advice gained from lectures and the technical officers to create a model AGV that fits the university's description.

In simplistic terms, an Automated Guided Vehicle is an autonomous vehicle that moves with the help of built-in software intertwined with electrical components . In our case, we used micro-python to code the software and used the keypad to control the vehicle. The specific requirements for this AGV was that it needed to contain the following:

- The wiring needs to be completed within the ESC, Optical Sensor, Battery and MCU

- The vehicle needed to pass the following tests: Line Test, Circle Test and perform 180º turn

- The steering mechanism needs the trapezoidal linkage attached to the servo

- Configuration of Microcontroller Unit, Configuration of the Arduino nano 33 BLE for microPython/OpenMV, Parts of the MCU need to be soldered together ,Completed Optical Sensor Investigation using Arduino nano 33 and Keypad attached to the chassis with configuration of micro python

- The vehicle needed a battery type of 7.2V

- Motor Speed controller, Motor Type had speed of 150 rev/sec with 7V applied attached with worm and Spur gear.

Overall there were many resources available at our disposal. Firstly, we'll look at the physical materials: Battery, Optic Sensor, MCU, Servo, Gears, Motor, MSC, Wheels and Keypad. These materials were the most vital segment of our AGV as we needed to put these in place, in a coherent and aesthetic manner. Without these resources, our guidance would've fallen astray as they were the specific constraints we had to follow. As well as that these resources took us the longest in needing to understand how they linked together.

Next, we'll move onto the tools used to fabricate the AGV: Hex Key, 3mm-4mm screws,nuts, lock nuts, bushings, ruler, metal sheet (chassis), pliers, axle, file, wrench. In addition to this, we used the engineering equipment in SG23 to mould the parts in our favour. Overall, we feel like these resources were adequate for the magnitude of our project as they helped in creating the chassis and putting holes inside it. Therefore, it gave a more finished look when we finished it. However, we feel as though a drill would have facilitated some of the tasks more efficiently.

Finally, we'll talk about the guidance from the technical officers. This was a crucial aspect in helping us understand the theory behind the previous resources. Without a doubt, this was our most valuable resource because when we got stuck in one of the labs before the fabrication, we could come to a solution easier. Especially, for the fabrication we gained excellent guidance from Liam Lawlor who showed us that our fuse blew ,that we should check our wiring and make sure not to add wheel brackets to the steering mechanism. As a result, we are able to get the best possible result from our AGV.

In conclusion, the process of being added to teams is a great idea as part of this project. We as a team feel like we have learned so much from each other and have built strong relationships that we can carry throughout our engineering course. We feel that this activity gave an opportunity to communicate in a more proficient manner as we learned from our meetings and design presentations. At first, being in teams was nerve-racking but eventually we found our flow and were able to express ourselves better. As well as that we feel as if this activity is supposed to enhance not only our engineering skills in a lifelong learning environment through the project but it is also there to strengthen our teamwork skills. This can be showcased through the labs, lectures and other resources that we utilised in order to strengthen our fundamental skills as engineers. Along with this, the way we were put in teams whereby we needed to negotiate each other's roles, work together in labs and assignments, communicate to other engineers about our project and share this project makes us think that this was another outcome obtained from this project.

Mechanical Design

Steering

Objectives: The main objective of the steering mechanism was to get the front wheels to turn by getting the inner and outer wheels to negotiate the turns at different angles. For this, we needed the back wheels to be perpendicular to the point it was turning from. As well as that, we needed the centre of the wheels to turn at an angle perpendicular to the point. This means that both the front wheels must be at the following angles: δi and δ_o. As a result, this makes the δi *greater than* δo. The reason for this is that the inner wheel has to turn more as its Ri is closer to the point at which it needs to turn. Consequently, we use the following equation to calculate the δi and δo angles: cot(o) - cot(i) $=W/L$. This facet of the steering mechanism is known as Ackerman's condition which is a crucial aspect to note when coupled with the trapezoidal linkage. In addition to this,we need to find the maximum steering angle : $\delta i\_max = tan\text{^-}1(L/R\_min-W/2)$. We use this when the car reaches when the radius is at its lowest value.

Another objective of the steering mechanism is to design the trapezoidal linkage mechanism which has 4 bars (2 angled and 2 horizontal). The two diagonal bars have the same offset arm length,d and the angle between the wheel and the corresponding arm is equal for both arms. This is known as β. The trapezoidal linkage is vital in turning the bars when the wheels want to change direction.

Therefore, both the trapezoidal linkage and Ackerman's condition are both interlinked for the steering mechanism to operate properly. This makes us approximate the Ackerman condition with a trapezoidal linkage mechanism. From the equations we used above: cot(o) - cot(i) $=W/L$ in the range 0 - δ_{i_max} and W/d. As a result, we create a graph of the range from 0 to δ_{i_max} and superimpose to the chosen ratio. Consequently, we are able to find the β.

The final aim of the steering mechanism was to get the servo arm to rotate to a maximum of 45º whilst maintaining the inner wheel at its greatest angle and be able to move the servo arm without any resistance from the linkage mechanism . This facilitates the horizontal movement of the horizontal bar(4th linkage).

Calculations:

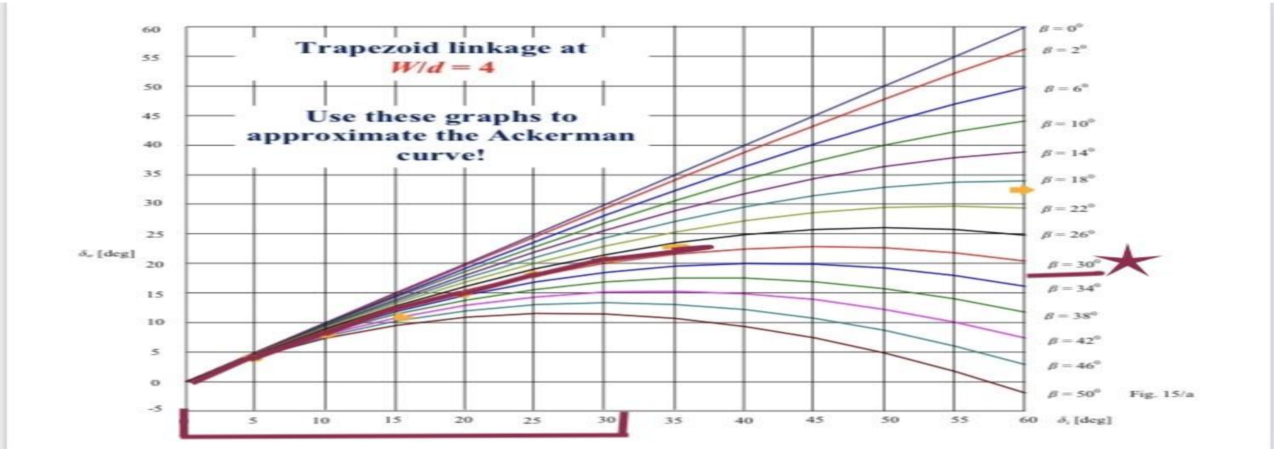
- ***Initial Design Presentation:***

Ackerman’s Geometry :

1) W/L = 1
2) W = 155mm
3) L = 155mm
4) cot(i) = (R_t -W/2)/L = 30 ≈ 30.5°
5) cot(o) = (R_t + W/2)/L = 20.17065° ≈ 20.17°
6) β=30º
7) W/d = 4
8) d(arm length) = 38.75mm
9) K = 17.60921691mm ≈ 17.61

K = 2dsin(inner angle max/2)cos(inner angle max/2 + β) - Change in horizontal movement of 4th linkage

Approximation of Ackerman’s condition and Trapezoidal Linkage:



We made the following changes from the initial design presentation. One of the changes that greatly impacted our AGV was W/L. We changed this to 278mm(L) x 202mm(W). There are many valid causes as to why we established this value. One of the main concerns was that both the front and rear wheels would hit off of the chassis. In the end, this calculation proved to be beneficial because if we had stuck with the previous design our wheels would not be able to turn due to the tight-spaced movement. The second reason as to why we changed our design was that we needed more space to fit the components such as the ESC(Electronic Speed Controller), motor, spur gear, battery and steering mechanism which took a lot more space then we had forecasted. In hindsight, we completely misjudged our expectations of the length of all the components from the component layout. Furthermore, we extended the height of our chassis by supplementing it with another floor which held our keypad, connected our wiring and MCU. Finally, we decided to change the length of the wheel-base and the track due to our calculations in relation to the steering mechanism. This was because we increased the value of the overall length of the 1st linkage bar to accommodate for the value of H. Furthermore, our beta value changed as a result of the new values. This value became 38º and the W/d ratio turned out to be 6 when we approximated it with the Ackerman condition.

Updated Calculations:

1) W/L = 0.73

2) cot(o) = 29.0255º = 29º

3) cot(i) = 42.9156º = 43º

4) B = 38º

5) W/d = 6

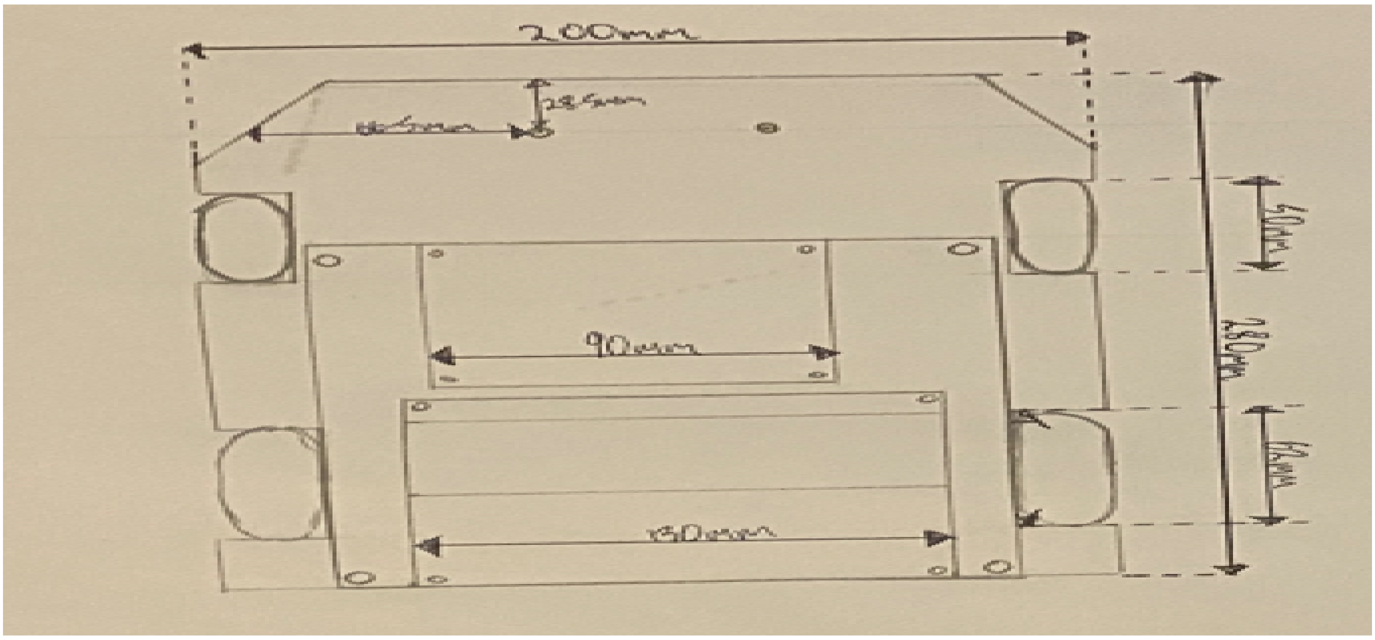
6) d(arm length) = 33.67mm

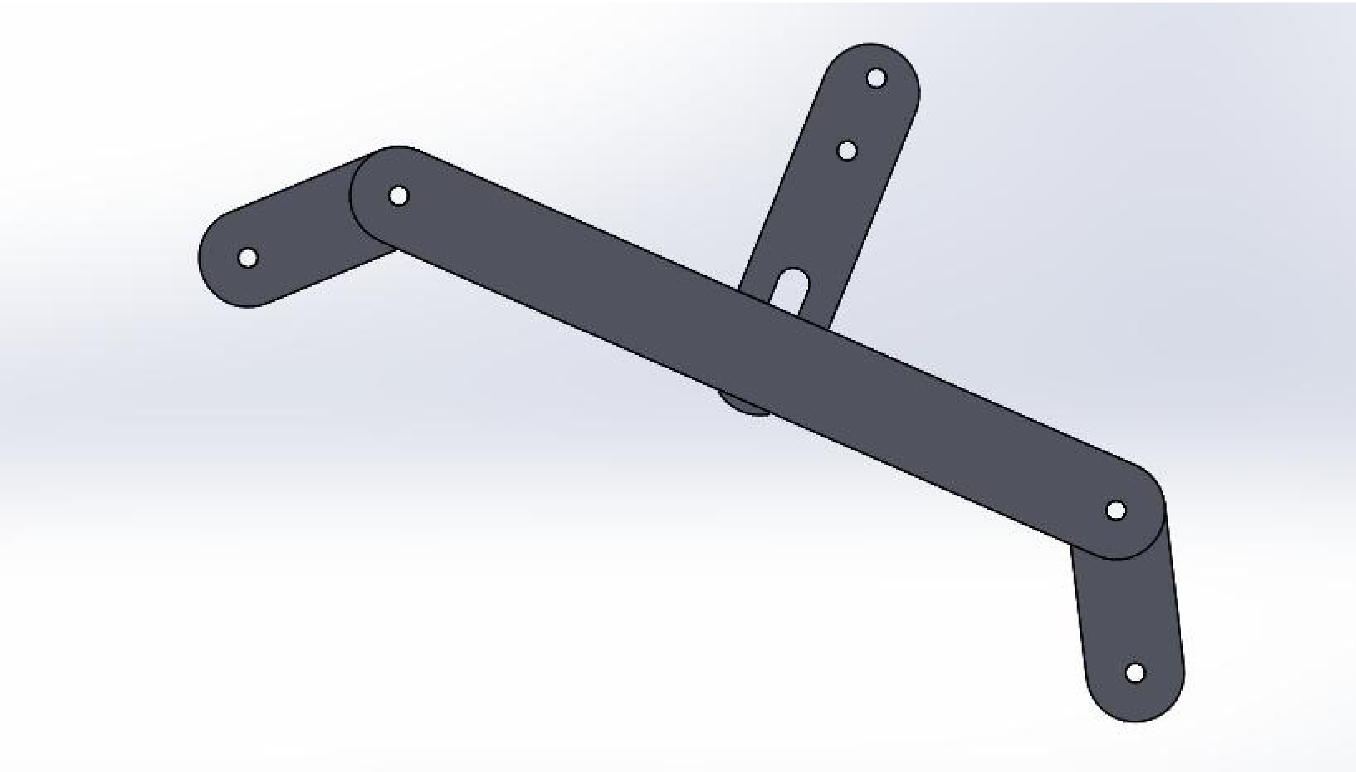
7) K = 12.526mm = 12.53mm

8) H = 23.5mm

Designing:

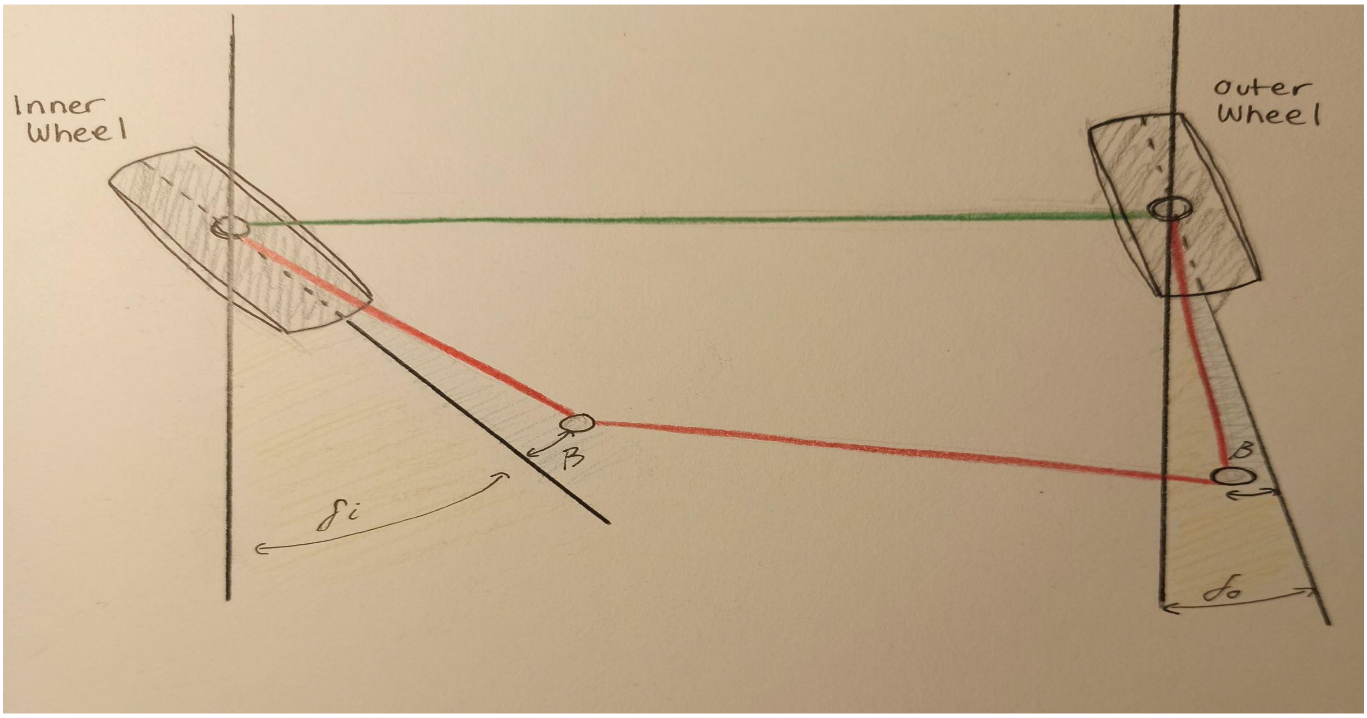
Initial Design Ideas



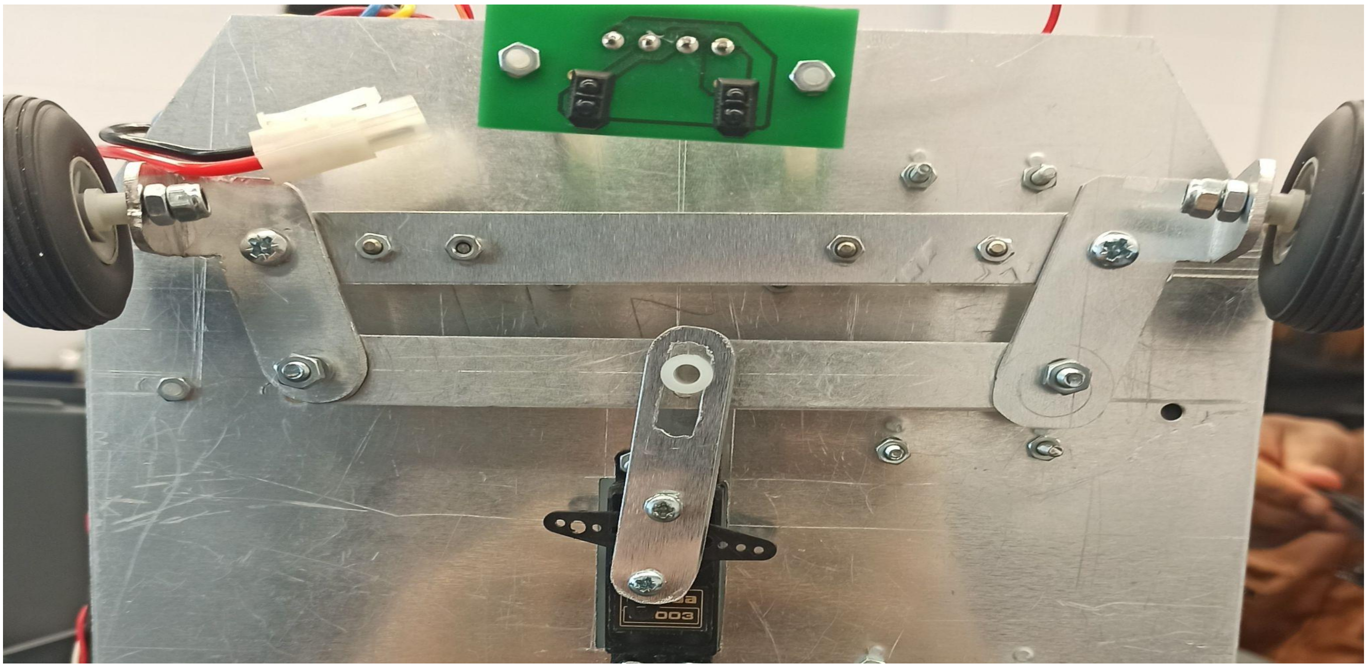


When designing the steering mechanism we changed many aspects from our preliminary design plan.

Firstly, when it came to designing the steering mechanism from a practical standpoint we had many ideas. We implemented many attempts before we came to our final design. Before the fabrication we mutually agreed to having the steering mechanism under the chassis as the wheels were placed underneath the chassis. In the first few weeks of the fabrication, we decided to add wheel brackets to uphold the wheels. From this point forward, we added 4mm bushings to the wheels with 4mm screws and locknuts. As for the diagonal arms(linkage 2,3) of the trapezoidal linkage system, we added 4mm lock nuts and screws to connect to from horizontal bar 1(linkage 1). As well as that, 3mm nuts went through the chassis in order to connect the horizontal bar 1(linkage 1) to the chassis. As for horizontal bar 4 (linkage 4) is connected to the diagonals where the angle beta is locked in. With this, another horizontal bar (holds servo) is connected to the 4th linkage. However, when we tested this our trapezoidal linkage bar 2 and 3 barely turned. The wheels wouldn't move properly. As a result, we changed our linkage system to the Final picture below. However, there were some issues with the wheels as they were slightly loose. Nonetheless, the trapezoidal linkage system functioned properly with the servo arm as the servo arm moved back and forth when we increased the speed during the testing phase. Furthermore, the horizontal bars 2 and 3 changed direction with great movement. Overall, the root of our problems came from our lack of decisiveness from the steering mechanism. We, as a team feel like if we had planned for failure rather than rely on our initial designs could have garnered a better result.



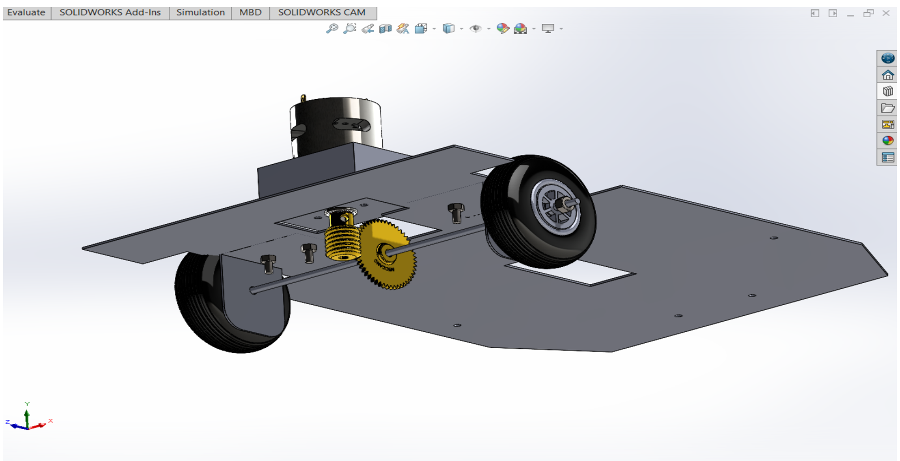
Final version of steering mechanism:

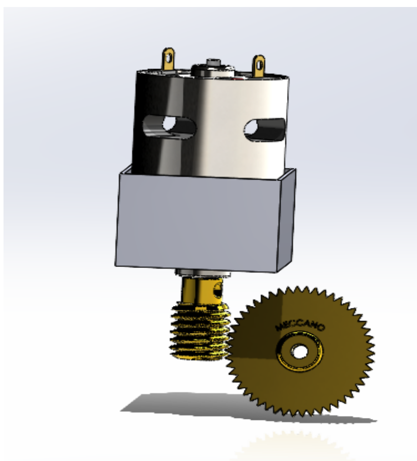


Drive

Objectives: The main aim of the driving mechanism was to provide power to the vehicle to give it the ability to drive forward and backwards. For this project a rear wheel driving mechanism was used, meaning that the power of the motor only caused the rear wheels to rotate. As a team we also had to carry out a number of calculations to further understand how the driving mechanism would function. Things that were taken into account for these calculations were the spur gear revolutions, the worm gear revolutions, the linear ground speed of the vehicle, the dimensions of the wheels, and the worm gear-spur gear transmission.

Elements: The driving mechanism was powered by a 7V DC battery. The electric motor (DC motor) had a maximum rotational speed of 8400 rev/min. The voltage could be varied between 0-7 Volts, therefore the motor speed could be controlled proportionally 0-8400 rev/min. The function of the electronic speed controller was to vary the voltage between 0 and 7 volts range. For the gear transmission a worm gear and a spur gear were used for this project. Finally there was the rear axle and two rear wheels of 57mm diameter.





(Ft. Rear wheel drive and worm gear-spur gear transmission. Made on solidworks.)

Calculations made for the driving mechanism: The maximum permitted speed of our vehicle was 30.2 m/min and the minimum permitted speed was 26.2 m/min. Using this information as well as the revolutions of the electric motor we were able to calculate the revolutions of the spur gear and then calculate the appropriate amount of teeth needed on the spur gear.

Spur gear revolutions: To calculate the revolutions of the spur gear we used the *Linear Ground Speed* formula which was provided to us in the driving and steering mechanism document. The formula was:

v = (Ln)(n)

Where:

- ➢ v = Linear ground speed (mm/s)
- ➢ Ln = Circumference of rear wheel (mm)
- ➢ n = Spur gear revolutions (rev/min)

Calculation:

- ➢ Maximum permissible ground speed = 30.2 m/min → 30200 mm/min
- ➢ Minimum permissible ground speed = 26.2 m/min → 26200 mm/min
- ➢ Wheel diameter = 57mm
- ➢ Wheel radius = 28.5mm
- ➢ Wheel circumference = (2)(π)(r) = 57π mm = 179.0707813 mm
- ➢ Spur gear revolutions for minimum 'v' = 26200 / 179.0707813 = **146.311 rev/min**
- ➢ Spur gear revolutions for maximum 'v' = 30200 / 179.0707813 = **168.648 rev/min**

Worm gear to spur gear transmission: We also had to understand that the rotational speed of the motor was too high for driving the rear axle directly. Therefore in this project a worm gear-spur gear transmission was used. The worm gear is the driving gear and is with a helical thread. It rotates about its axis with a rotational speed 'nw' rev/min. The spur gear is the driven gear. It has 'Ns' number of teeth and rotates about its axis O with rotational speed 'ns' rev/min. For one revolution of the worm gear the spur gear rotated one tooth. We learned that the spur gear rotated 'Ns' times slower than the worm gear. This was demonstrated using the 'Transmission ratio' formula and hence we could calculate our desired number of teeth on the spur gear. The formula was as follows:

T = nw/ns = Ns

Where:

- ➢ T = Transmission ratio
- ➢ nw = Worm gear revolutions rev/min
- ➢ ns = Spur gear revolutions rev/min
- ➢ Ns = Number of teeth on the spur gear

Spur gear teeth Calculation:

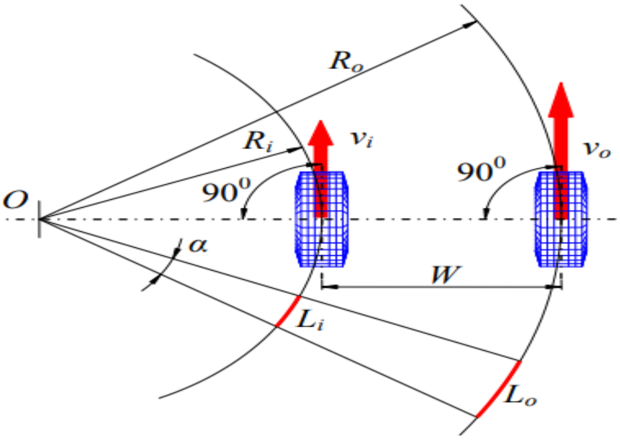
- ➢ Electric Motor revolutions with 7V applied: 8400 rev/min
- ➢ Spur Gear revolutions: 146.311 rev/min (min speed), 168.648 rev/min (max speed).
- ➢ Maximum amount of teeth (min speed) : 8400 / 146.311 = 57.41 → 57

- Minimum amount of teeth (max speed) : 8400 / 168.648 rev/min = 49.807 → 50
- We calculated the range of teeth to be between: **50 ≤ Ns ≤ 57**
- We also noted down that the greater the number of teeth the faster the vehicle goes.
- In addition to this we also varied the number of teeth in that range to see what speeds the car would achieve with a different number of teeth. The table below shows how we carried out these calculations.

No. of teeth	Motor revs/no. of teeth calc.	Spur gear revs (rev/min)	Wheel circumference x spur gear revs calc.	Ground speed (m/min)
50	8400/50	168	179.0707813x168	30.08
51	8400/51	164.71	179.0707813x164.71	29.49
52	8400/52	161.54	179.0707813x161.54	28.93
53	8400/53	158.49	179.0707813x158.49	28.38
54	8400/54	155.56	179.0707813x155.56	27.86
55	8400/55	152.72	179.0707813x152.72	27.35
56	8400/56	150	179.0707813x150	26.86
57	8400/57	147.37	179.0707813x147.37	26.39

As a group we decided to go with 50 teeth for the spur gear. We knew that the rotational speed of the motor could also be controlled by the electronic speed controller which would reduce the revolutions of the worm gear and hence have an automatic effect on the spur gear revolutions. Therefore our decision was to go with 50 teeth.

Turn Negotiations: When the AGV would negotiate turns around a point at centre ‘O’. It was necessary for the axle of the wheels to cross point ‘O’ in order for the longitudinal axis of the wheels to stay tangential to the circle (with centre ‘O’) at all times. This action would allow cornering to happen without the wheels skidding. We learned that driving both wheels would be advantageous as it would distribute the force required to move the car evenly between the two wheels, however this would cause issues when cornering. We learned that in order for the AGV to carry out a turn smoothly, only one wheel would be used for the driving while the other one would be ‘free wheeling’. This is because when the AGV would negotiate a turn around a centre point ‘O’. The inner wheel needs to turn around a sharper angle than the outer wheel. Therefore the outer wheel has a greater distance to travel and must rotate at a higher speed than the inner wheel. This is why driving both wheels was avoided during this project. An explanation of this is demonstrated in the diagram below which was extracted from the driving and steering mechanism document.



Manufacturing of the driving mechanism: The components which had to be manufactured for the driving mechanism were: Back wheel brackets (x2) and a Motor holder (x1). In addition to that we had to create an opening in the chassis as we knew that the spur gear may protrude through it. We also had to thread the axle in order to screw the wheel on.

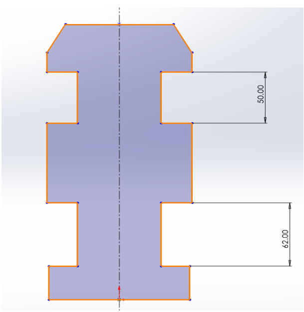
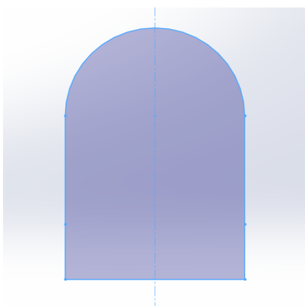
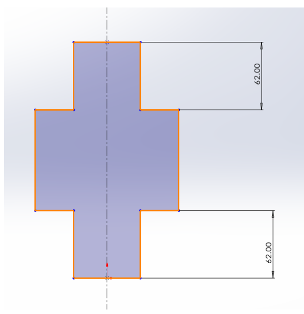
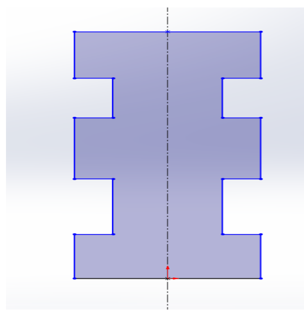
Problems Encountered and solved: Our first prototype of the driving mechanism had one flaw. The issue was that only a few teeth of the spur gear interlocked with the worm gear meaning that our spur gear was too low. This would have an effect on the mechanism as the power transfer between the gears would be smaller and therefore it would provide a weaker torque to the axle and the wheels.

This problem was resolved by manufacturing new brackets and using the hole punch to make new holes located higher on the brackets.

Chassis

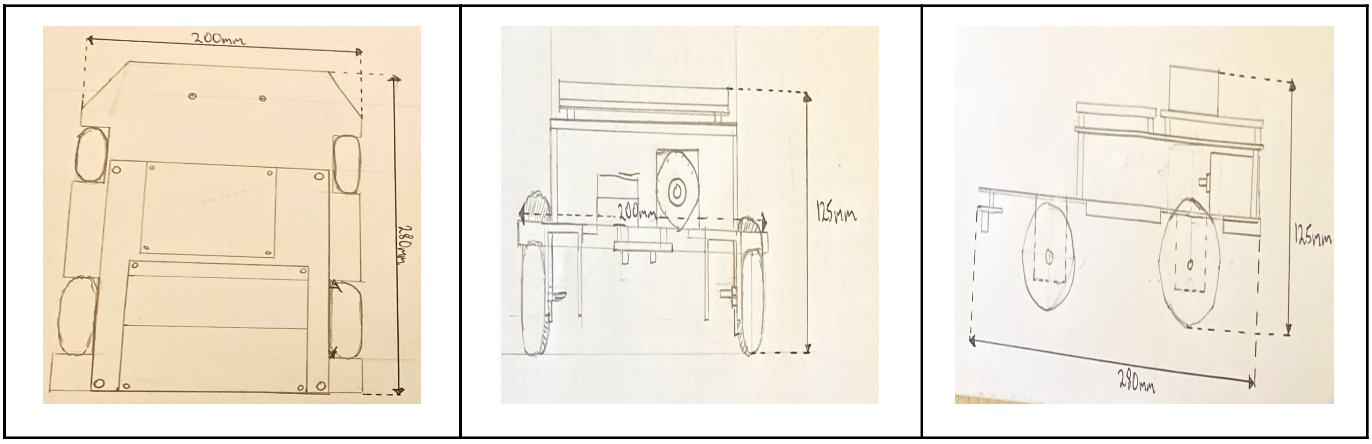
Objectives: The main objective of the chassis design was to plan and manufacture a chassis that will hold the drive and steering mechanism and also the MCU. The chassis had to be less than an A4 page in width and length. We had also made additional requirements for the chassis design. We wanted the chassis design to be simple, so more time can be spent on refining / reiterating other parts. We also wanted the chassis to not take up much space vertically.

Designing: With the design requirements noted, we drew up initial designs of four different chassis on SolidWorks. We took inspiration from the previous first year projects and compiled my favourite ones to show to my group members. We decided collectively on a design (The first design from left to right in the table), and I started to go into heavier detail with the design.

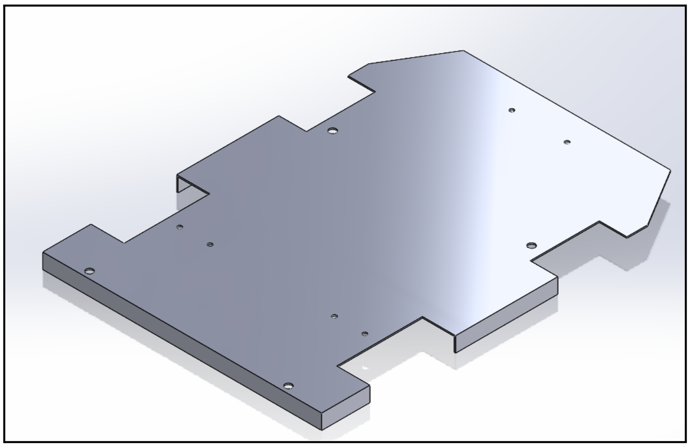
			

(The initial designs)

We first drew the top, front and right planes of what the finished project would look like on paper, with everything assembled, and then began creating a solidworks part of the chassis.



(The top, front and right views of the sketches)



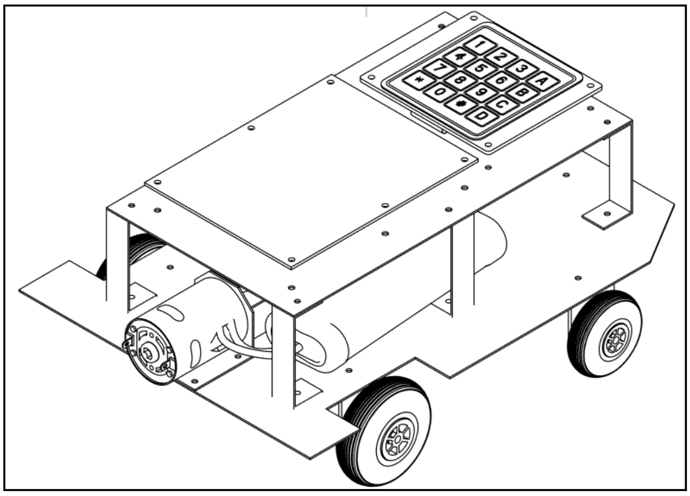
(The chassis drawn up in solidworks)

After designing the chassis, we started to design other parts of the AGV, such as the front and back wheel brackets and the MCU component holder. These were only initial designs, and they went under numerous iterations throughout the workshops.

Problems Encountered and Solved: There were several problems with the designs of the brackets and the chassis. These problems were only found during fabrication of the parts. A good example of one of the problems we encountered was the flaps on the initial chassis design. They were hard to fabricate properly without making it seem more of an eyesore.

Another design problem was the front wheel brackets were too small, and they needed to be changed in order to fit the linkage system. In total, the front wheel brackets went under three different reiterations until it suited the linkage system.

There was also a problem with the wiring of the components. A lot of the wires were too short / had to travel unnecessarily long distances in the AGV. This was a design flaw we did not see, as we were only visualising it through SolidWorks.



(Assembly of the AGV in SolidWorks)

Component Layout: For component layout, we decided that we should put the PCB and the keypad above the other components, on a components holder. Next, we planned on placing the motor at the rear middle of the AGV, to provide balance and support to the vehicle. After the motor, we planned on placing the servo motor near the centre of the vehicle, as that was where the linkage system would be. We also planned on using a servo arm that connects the servo to the linkage system. We placed our battery and ESC in the centre of the vehicle to provide balance to the vehicle while it turns.

MCU Construction and test

The MCU fabrication was done during the MCU Construction lab, where we soldered the needed components into the PCB and later tested the board in a different lab. We learned about the layout of the components, what each component did and how to solder the components into the PCB during the labs. As a team, we appointed different roles in order to complete the fabrication as efficiently as possible. Aleksander Lanecki looked over the component sheet to see which components were needed next, Alfie Antony viewed the layout of the printed circuit board to ensure that the components were placed in the correct positions and Anthony Clarke and Zygimantas Gricius soldered the components into the PCB.

The control signals generated by the MCU first start at the Arduino, where it detects a change in light levels from the optical sensors. The arduino sends a signal to the driving mechanism, telling it to stop turning the motor. The steering mechanism is then told to turn until the optical sensors give readings of a high light level. When this happens, the Arduino tells the driving mechanism to function again.

During our test lab, we tested the LCD display, keypad, optical sensor PCB, and the motor control for both driving and steering, using various codes written in micro python. We first tested the LCD display with a code that displayed different text on the LCD. We experimented with the code by commenting out various “tests” and adding our own to see how the LCD would respond.

After the LCD display, we tried to test our keypad. However, we ran into a problem with our PCB. There was a weak solder connection between the keypad connector and the PCB, which caused our code to read nothing from the keypad. We didn’t realise what the problem was at the time, so we asked an instructor to assist us.

When our PCB was resoldered, we used code that would display what key was pressed in the terminal of our openMV IDE. We tested each key, and confirmed that the keypad was in working order. We then tested the optical sensor PCB to ensure its functionality. We used code that displayed different sensor data into the serial terminal depending on the light levels being detected by the optical sensors. We investigated the capabilities of the optical sensors by placing them at different heights, showing the sensors different colours ranging from white to black and testing the sensors individually.

After the optical sensor testing, we examined the motor control, specifically the servo motor first. We used code that would rotate the servo motor 45 degrees to the left and right. When we verified that our servo motor was functioning properly, we changed the code to test the drive motor instead. The motor would turn for a certain amount of time and rotate back after its initial revolutions. We changed variables within the code to change the speed and time of the motor.

Vehicle Integration and Test

Basic functionality:

During the workshop labs we undertook tests that showed us the basic functionality of our vehicle. We had one lab where we tested each component individually using the MCU and the python code which was provided to us. We tested each hardware subsystem and the required peripheral devices for our AGV. During the lab we were happy to see that each component worked without any further issues.

Once we had our vehicle fully assembled with all the components required for it to drive we mounted the 7.2V battery and connected it to its designated place on the MCU. However before we mounted the battery we checked to see if it would provide power to the vehicle first. We did this by using a multimeter and setting it to DC voltage. The readings on the multimeter were between 6.9 and 7.1 Volts. This meant that we could proceed with our testing. We also had to make sure to connect the electronic speed controller (ESC), the motor, the optical sensor, and the servo arm to its designated connections on the MCU. Finally we connected the Arduino Nano 33 BLE to the MCU and connected it to a laptop using a USB cable. We extracted all the python code necessary for all the devices to be able to function and hence manoeuvre the vehicle.

We began with the servo testing which would allow for the wheels of the vehicle to turn. The servo successfully rotated to the -100% position (45° counterclockwise) and +100% position (45° clockwise). Knowing that our steering system had the ability to function we carried on to test the driving mechanism using the tract test. Between the -10% and 10% (- was for the vehicle going in reverse and + was for the vehicle driving forward) zone we noticed that the motor was stationary. At first we thought there was some malfunction however we came to the conclusion that this could be the ‘dead zone’ where the motor simply doesn't have enough power to rotate and provide torque for the worm gear. We therefore increased the tract percentage until we started to notice significant changes.We placed our AGV on the floor and tested it at 50%. The vehicle began to drive.

Unfortunately the vehicle only drove briefly (for about five seconds) before all the systems stopped working i.e the MCU shut off completely. This was quite concerning for us as a team as we didnt know where the problem was arising from. We thought that it had to be a problem with the power and it turned out that the fuse from the battery had blown. At first we thought that it may have been faulty but it wasn't too convincing when another two fuses blew after that situation. We consulted one of the demonstrators in the lab who had a look at our setup as we didnt know where the problem was arising from(We had everything connected in the right ports.). We found ourselves to be in a difficult situation because our wiring seemed to not be the problem. It turned out that the source of the problem may have been the ESC (Electronic Speed Controller) which controlled the power provided to the motor (from 0 - 7 Volts).Unfortunately we didn't have enough time to resolve the problem in order to carry out the remaining tests. However as a team we did come to the conclusion that maybe some of the wires from the ESC were mixed up and this is something which may have caused the problem.

Enhanced functionality: Line Capture

During the testing of individual components we were happy to see that our optical sensor functioned in line with our expectations. The optical sensor was a key component when it came to capturing the line. It could detect reflective material such as paper or magnetic tape for example. This would enable the vehicle to keep its path and not go off it (The Line Test). During the peripheral device testing lab we were happy to see that our optical sensor functioned when we put it over a light surface (piece of paper).Gave us a reading of 3.28V when the surface was detected.

Unfortunately we weren't able to proceed with the line capture and circle test due to the problems we encountered with the ESC.This was a shame as our optical sensor did not encounter any problems when detecting reflective surfaces However as a team we believe that our vehicle was capable of completing these tests.

Teamwork and project management

The AGV as a whole could never have gone ahead without the combined efforts of our team members. We all had different roles and responsibilities that coincided with what each of our unique skills were. We each made sure our tasks were completed and then would check up on each other. Luckily we each found that as a team we would support one another through any difficulties. No matter the issue, if we texted in our group chat, it would be solved together. As a core, we believed that any problems we individually ran into, would be an issue that the entire team would run into.

We first decided who would do what after our first ever meeting, from the library, to which we all agreed that it would be paramount to get our skills and attributes out of the way. It was quite simple and straightforward as we soon figured that we had very specific skill sets. Zygimantas Gricius was given chassis design. This coordinated very well, with his past projects in his Leaving Cert practicals being Technical Graphic designs. He was very confident in this role and he was effective at processing his LC skills to the AGV project. Aleksander was given the driving mechanism. He offered himself to take this role as it wasn't something that we all had been familiar with in the past, and he felt that he could take it on quite well. Alife was very skilled at mechanical engineering and mathematical processes and so it was only right to be given the steering mechanism. He reached his set out standards quite well, which was the perfect outcome for us as a team as we all, but Alfie, didn't feel as strong when it came down to certain aspects of the mechanism. Finally Anthony was given the opportunity to be the team coordinator, and it worked perfectly for his specific skills in management, cooperation and communication. He held the team accountable and made sure each member was living up to their roles that were given to them. The team worked fluidly and perfectly with one another, and we found that if our roles were given differently, it could have ended with quite varying results.

When it came to how we cooperated at a team based level, we each had very unique ideas and perspectives to add to the design process. We dealt with each new idea very democratically and made a space that created freedom to discuss and question any decisions and choices that were made. It got to a point where we would question each other on what we did with our specific roles, and learn from each other in a way that was interactive and adaptive. We explained our motives and goals for our roles, and would come together during every lab workshop to discuss in depth the next move to make. The team was open to new recommendations and we were adaptable to any new issue we ran into as a team. For example, we had at one point realised that we made some miscalculations relating to the steering mechanism, but it was a simple issue when working together. It first started as a shock to us but as we recollected ourselves quickly, we soon started to work perfectly together. Anthony made new measurements for the pieces, Aleksander started building the new linkage part, Alfie calculated the new degrees, and Zygimantas worked out which was incorrect about the pieces.

Conclusion: Learning Outcomes

As a team we think that the AGV Design Project has taught us many new skills in the branch of engineering. It was a really interesting and valuable learning experience and even though we are all splitting up to our chosen courses next year, this project is something which will benefit us no matter the course that we chose.

During the project we tried to divide tasks in accordance to our strengths, however there were a few new aspects of the project which were completely new to us, but we treated these more as learning opportunities. The new tools which we learned to use were Solidworks when it came to designing the components and devices, and Python (Coding Language) which we used to control these devices and hardware subsystems.

We need to admit that some aspects of the project were not easy, however we did enjoy solving these problems together as a team. For example when we encountered a problem with the steering mechanism where the trapezoidal linkage wasn't of the right dimensions, we quickly organised ourselves and divided tasks to each team member to fix the system as quickly and as efficiently as possible. This also applied to fixing other components during the labs.

A few suggestions that we ,as a team, think should be implemented for future engineering students is that the online lectures should be moved to more on campus lectures. The reason we believe this is that we as a team found ourselves looking back over the information again, even after the lectures. A different suggestion that we believe should be in place is that the expo(poster presentation) should be in a different venue altogether whereby INTRA employers can see the potential of engineering students in the first year. Here, they would be able to provide their own input and we, as engineering students, would be able to apply the information when working as part of a team for our INTRA. Overall, we believe that these recommendations can empower the future generation of engineering students.

References

- Car Driving and Steering Mechanism document
- Nano 33 MCU hardware Test exercise worksheet