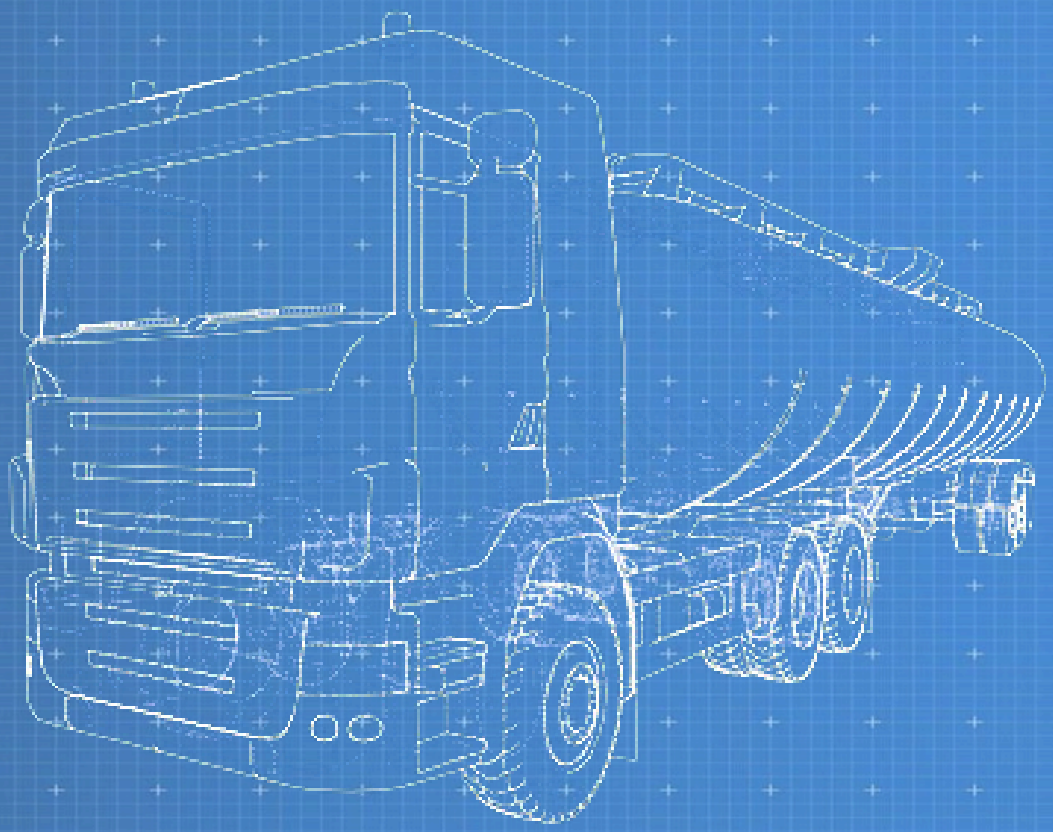
Science Fair 2025

# Project Log Book

## Safer Roads Ahead



Mason Chen

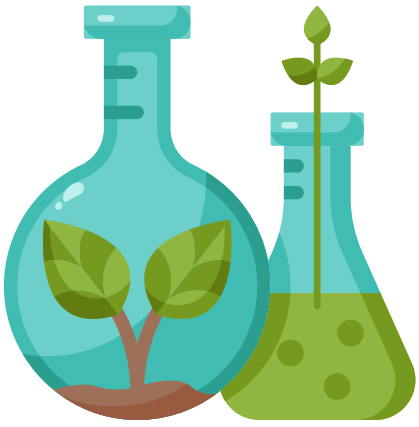
# August 2024

# Week 1

I Researched prominent current issues and determined a potential project idea. After doing some more research, I figured that every year, thousands of incidents occur with fuel tanker trucks. These incidents can be fatal and/or lead to serious pollution. They are mainly caused by destabilising effects, such as liquid sloshing, sudden abrupt manoeuvres causing rollovers, and large fuel spills. During more of my research I found a lot of statistics and information.

# Week 2

I combined the current issues in our society with my interests, and I managed to formulate a project idea: Using 3D modeling and printing assisted by AI to design optimized baffles that reduce tanker sloshing, enhance stability, and minimize spill risks, ultimately improving safety and environmental protection.



# Week 3 & 4

I decided to use my existing material, tools, and toys to simulate the real-life scenarios, and test my baffle designs. This approach keeps costs low and is feasible to complete at home.

Having now gained a comprehensive understanding of the severity of this problem, I will brainstorm on how to address this pressing problem.

# September 2024

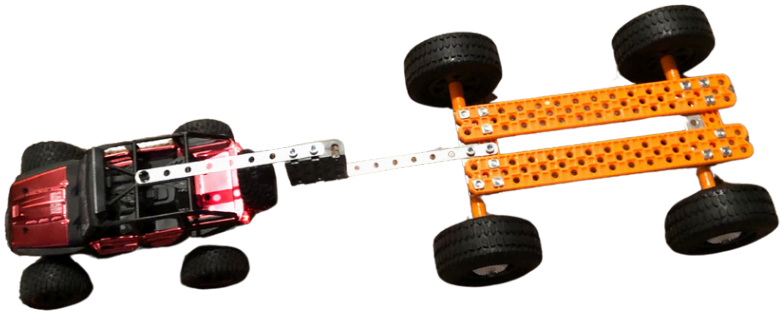
# Week 1

I built a few trailer systems with pre-existing materials like Meccano Toolkit, which the tankers would attach to. I also built an attachment to connect a RC car to the trailer using a top mount mechanism.

The first systems did not allow for smooth turns, rather a very tight turning angle, and flipped the tractor and trailer.

# Week 2

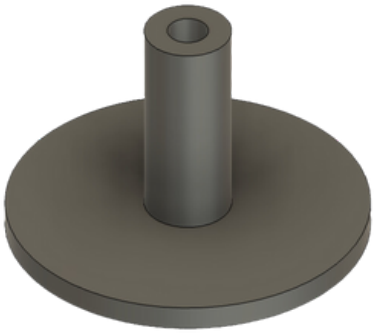
I created the third version of the trailer system with angle constraints, which worked, but the top mount approach could not mimic the real trailer system as the fuel tankers on the road.



FAILED

# Week 3

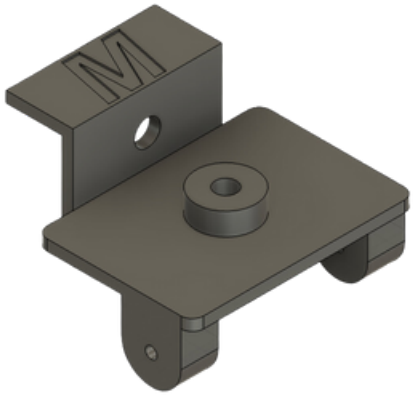
I modified the scale of the trailer to fit the ratio of the RC car. This later required me to 3D model new custom wheels to be fitted on tires found in a robotics kit.



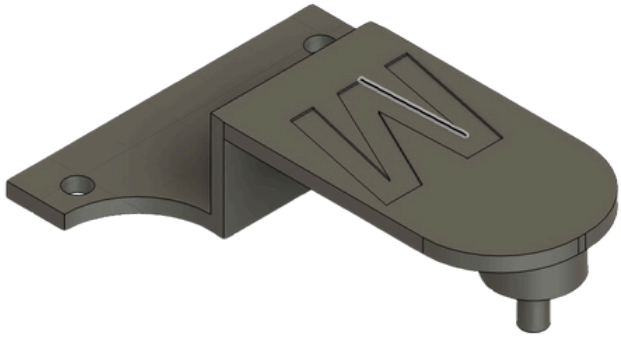
PASSED

# Week 4

I decided to fully redesign the whole system with a 3D printed gooseneck system. It mounted to the RC car via screws and bolts, and the other sides mounted to the underside of the trailer and worked successfully.







# October 2024

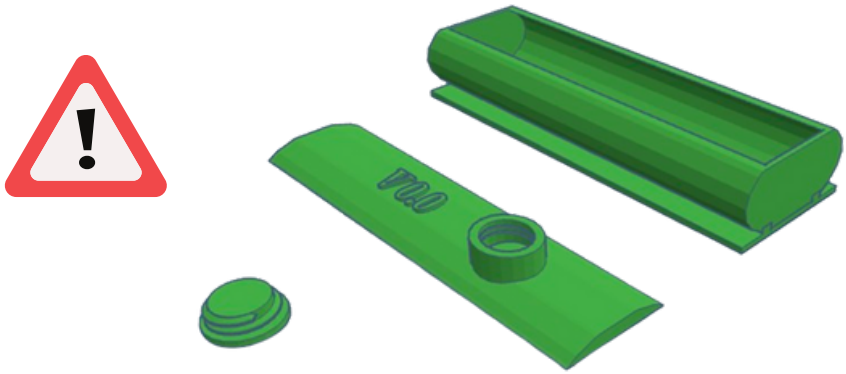
# Week 1

I focused on the tanker part of the project during this month. At first, I planned to find an existing STL file of a fuel tanker from the internet. However, this proved to be difficult as I could not find any that fit the needs of my project and criteria.

I made the decision to 3D model a replica of fuel tankers at a smaller scale by myself. This process was very tedious with more than ten prototypes of tankers until I landed on one that satisfied me and the requirements.

# Week 2 (1)

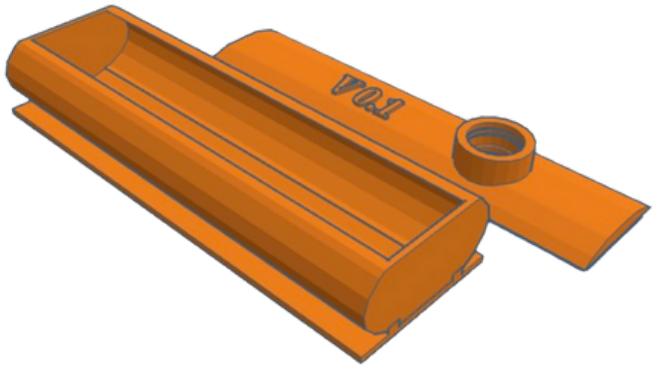
My first couple of prototypes were created on TinkerCad, an online 3D modelling software. However, later into this project, the limitation in features of TinkerCAD turned to a bottleneck.



My first design was a very tiny closed one piece tank, however, due to a 3D printer's limitation, it is unable to print overhangs (a part of the model that extends outward without support underneath).

# Week 2 (2)

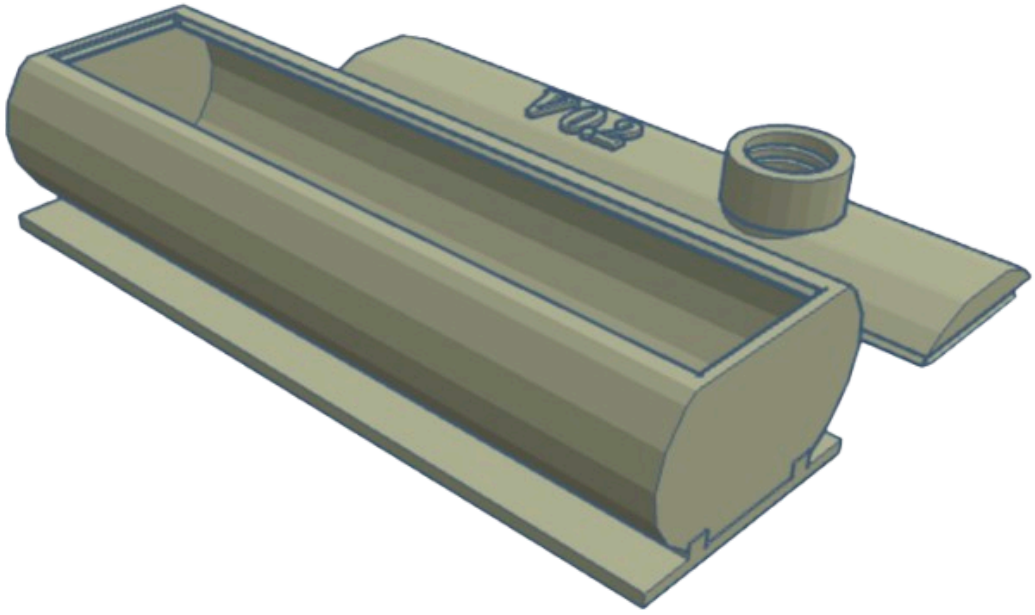
In my second design and all the following, I separated the upper part of the tank to have a lid. This did remove all overhangs, however, it complicated the design by a lot, and also required very precise 3D modeling and printing.




My second design failed as the lid did sit flush on the top of the base part of the tanker, but it had nowhere to grab on to, eventually falling into the base. I learned that I needed to create a groove to allow the lid to stay securely.

# Week 3 (1)

In my third design, I made a groove for the lid to grab onto the base, it did not fit well as TinkerCad lacked accuracy.



DEFECT

# Week 3 (2)

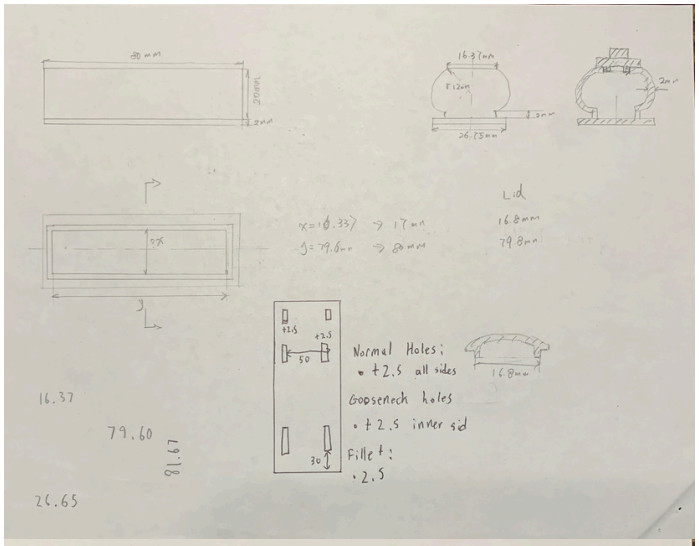
After some investigation, I decided to adopt and learn Autodesk Fusion 360, a professional CAD 3D modelling software (Thanks to Autodesk for providing access to professional software free to students).

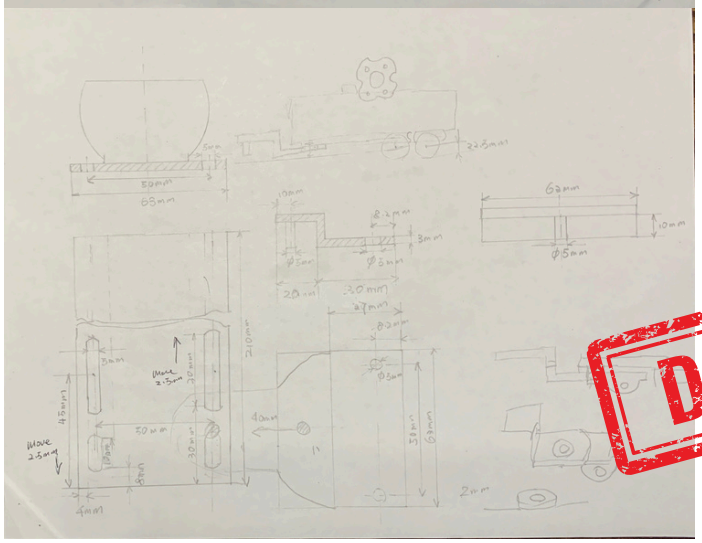
This meant that I would have to restart all over again because I was unable to export my files from TinkerCad into Fusion360. The learning curve was also very steep, as little experience in TinkCAD could be transferred into Fusion 360.

RESTART

# Week 3 (3)

During this time, I made blueprints of the designs I would be creating in Fusion, making sure I had precise measurements, making the entire process more streamlined. Some blueprints are shown below.



# Week 4 (1)

My designs in Fusion were a lot more accurate, and I was able to quickly remodel whenever I needed to modify and adjust the designs.
I modeled a twist on cap for the lid so that putting liquid for testing would be easier. This took many tries because the tolerances on 3D printers are not very precise.

I was able to finalize the base of the tank, however, the lid of the tank was very fragile, and could easily be cracked. It took me a total of three tries to perfect it.

# Week 4 (2)

In my final versions, I added pilot holes into the base of the tank to make attaching it to the trailer easier.

FINAL

# November 2024

# Week 1

I brainstormed many baffle designs that I would 3D model. This was difficult because I needed to be very creative while still being practical.

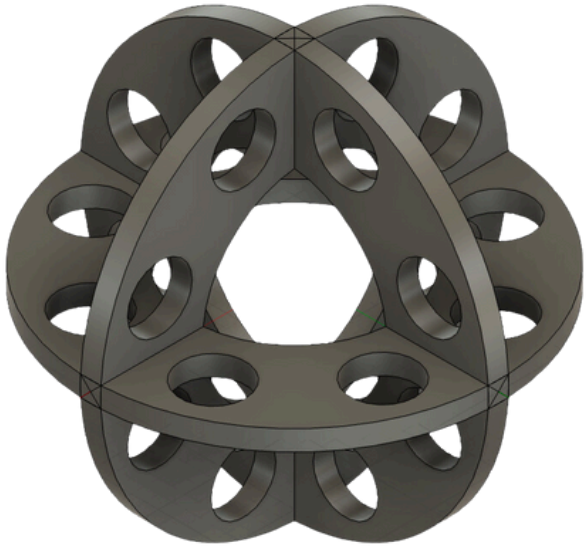
At first, I consulted ChatGPT for some ideas and inspiration for baffle designs. This proved that ChatGPT was unable to provide any insightful and genuine ideas at all.

# Week 2 (1)

I modeled the standard baffle first because it was the simplest and always used as the baseline.

# Week 2 (2)

Next, after performing some research, I found my next baffle design. The baffle ball, which is a ball constructed from three round plates assembled together to make a ball.

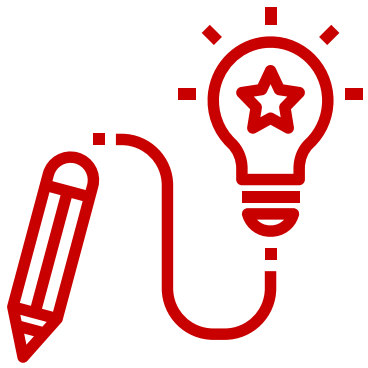


For the baffle ball, I 3D modelled and printed them assembled. In total, I put seven baffle balls in the tanker.

# Week 3 (1)

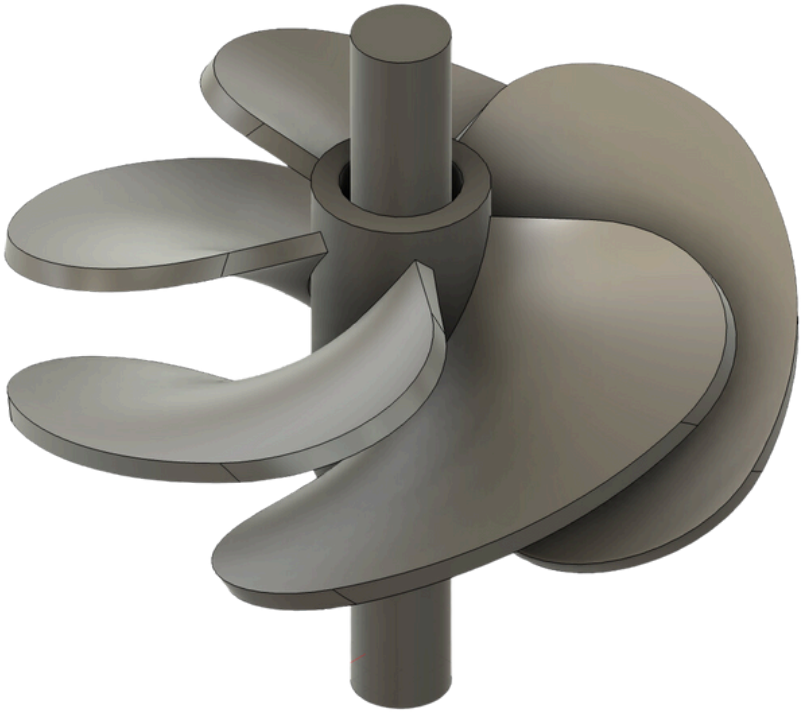
I came up with three different baffle designs which were a propeller baffle that would redirect the liquid into controlled patterns.

Because I did not want to print and test three more very similar designs, I consulted ChatGPT to provide some insight into which design would be the most effective at reducing sloshing and wave amplitude.



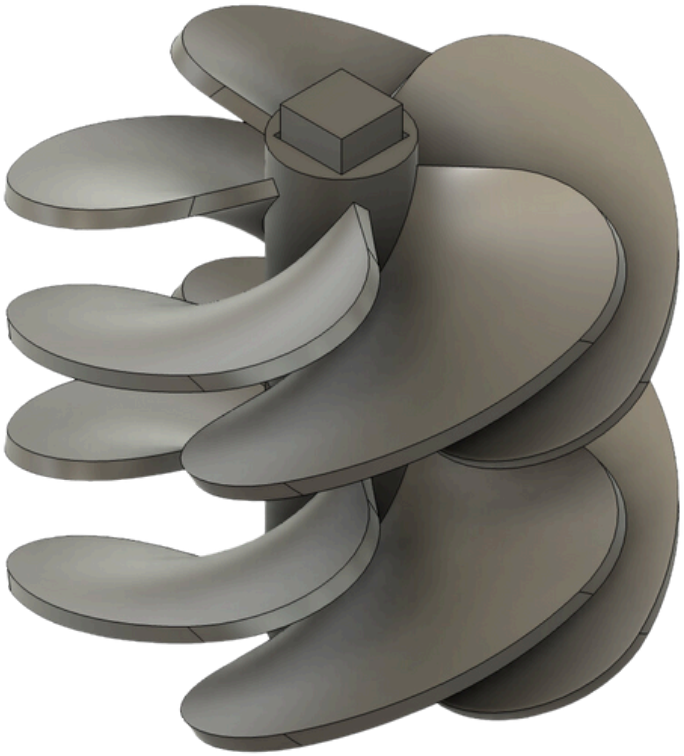
# Week 3 (2)

The first one was a freely rotatable propeller baffle that was dynamic with the liquids in the tanker.



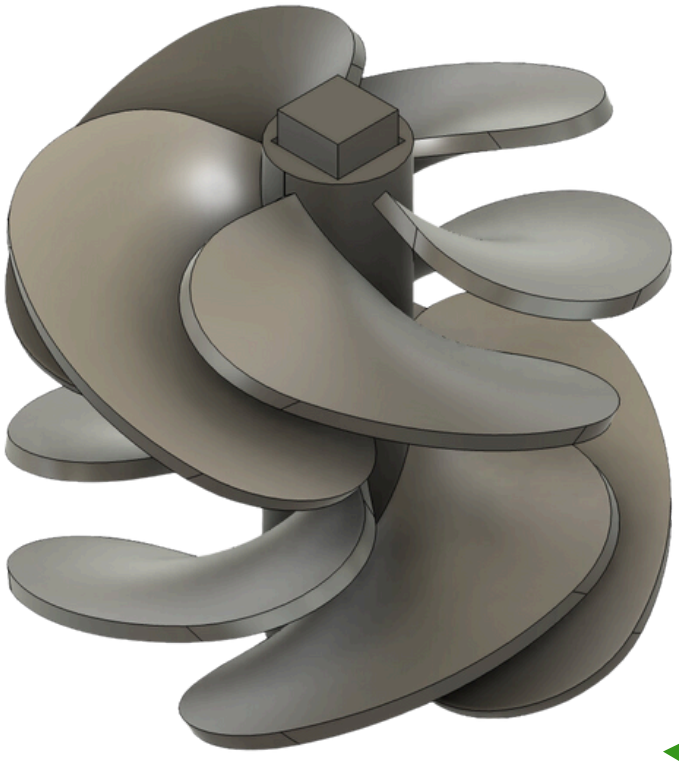
# Week 3 (3)

Based on this design, I was able to tweak it to make it static rather than dynamic while still facing the same direction. This would allow for the liquid to be forced into a controlled circular motion.



# Week 4

I was then able to tweak it even further. Stacking static propeller opposite-direction baffles which the fixed propellers with opposite spiral directions would create a swirling motion. This forces the liquid into controlled circular paths, thus significantly increasing energy dissipation.



# December 2024

# Week 1 & 2

During this time, I finalized all of my 3D models and 3D printed all of them so that I have an entire set that is ready for testing when the time comes.

# Week 3 & 4

I was also able to put together the majority of my write up which contains all of the details from this entire project.

# January 2025

# Week 1 (1)

During this time, I planned the scenarios, in which I would test/experiment the baffles.

Testing Scenarios: The RC tractor and trailer were tested repeatedly (10 times for each solution with each challenge) under controlled conditions.

- Liquid amount: 210ml water
- Acceleration distance: 270cm

# Week 1 (2)

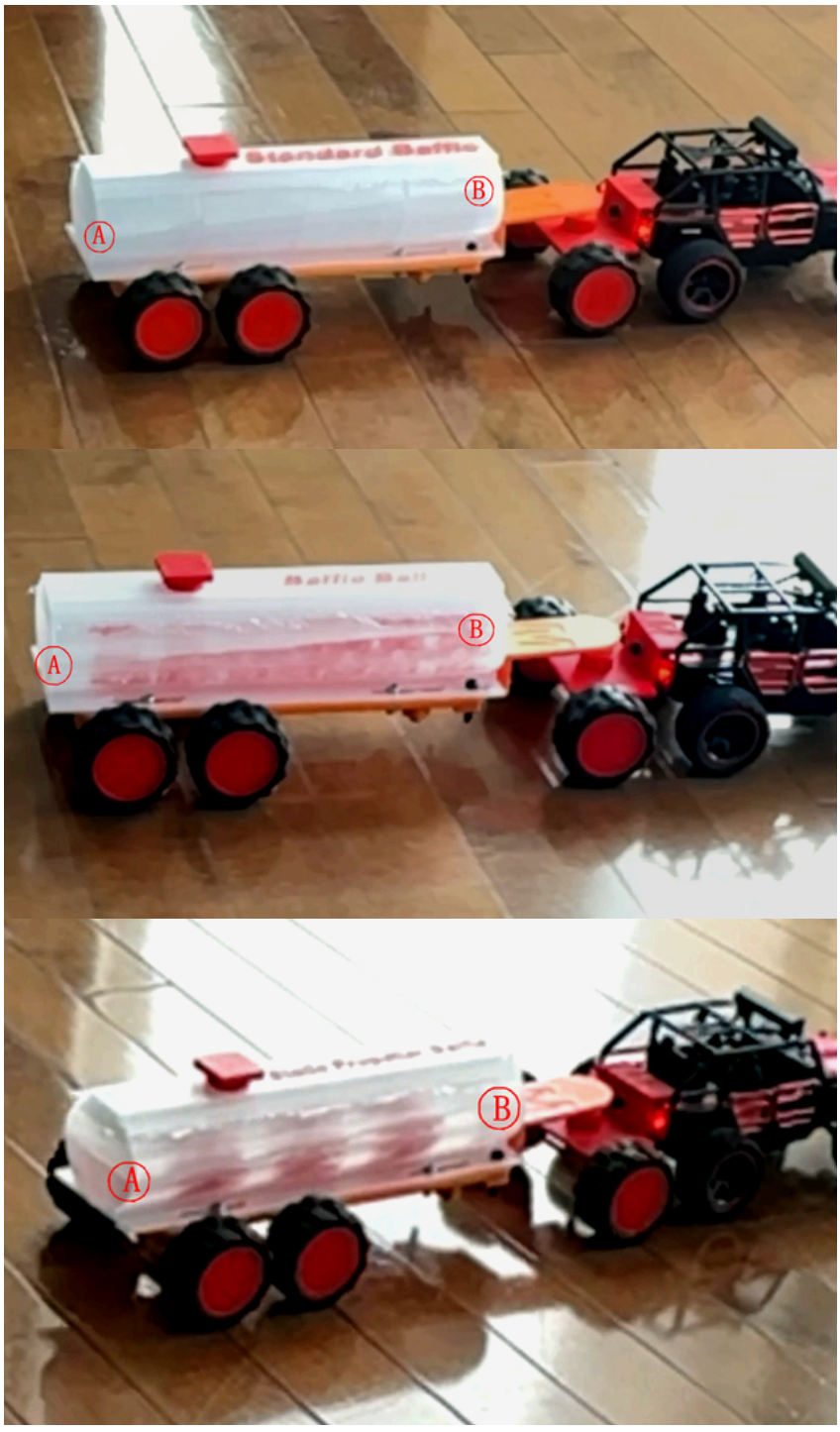
To simulate real-world tanker challenges

- Straight-Line acceleration and deceleration: To observe sloshing during sudden stops and starts and measure the braking distance.

- Sharp turns: To measure the tank’s resistance to rollover due to liquid inertia and measure the stopping distance after turns.

# Week 2 (1)

The below are the test scenarios with the different baffle desings.



# Week 2 (2)

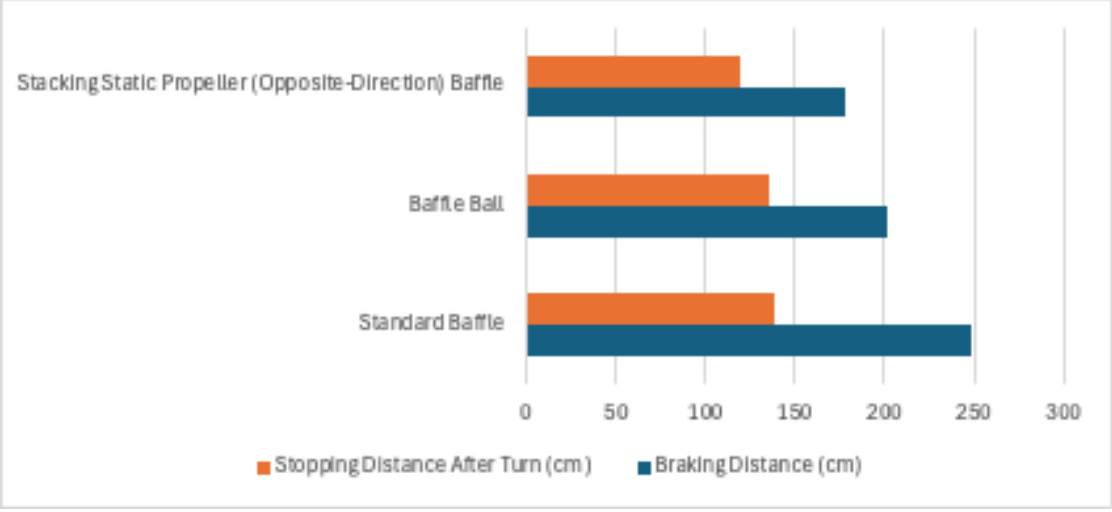
I analyzed the data collected from the series of tests.

According to the testing results, compared to the baseline (standard baffle), the average braking distance of baffle ball and stacking static propeller (opposite-direction) baffle respectively reduced by 19% and 29%, and the stopping distance after turns reduced by 2% and 13%. The graph shown below is the data collected.

# Week 3

See the test result data and graph below.

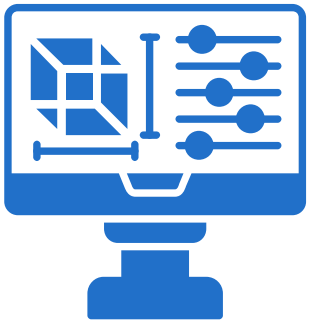
| Solution | Sloshing Level | Rollover Risk | Braking Distance (cm) | Stopping Distance After Turn (cm) |
|---|---|---|---|---|
| **Standard Baffle** | High | High | 249 | 138 |
| **Baffle Ball** | Medium | High | 201 | 135 |
| **Stacking Static Propeller (Opposite-Direction) Baffle** | Low | Low | 178 | 120 |



# Week 4 (1)

During this month, I began research on CFD simulation, in which I would be able to simulate my baffle desings with more accuracy.

I decided to adopt a software called SimFlow, a proffesional CFD software. I followed the given tutorials, and was able to simulate tanker sloshing without andy baffles. However, because I was using the free version, I ran out of Nodes, and was unable to continue simulation.



# Week 4 (2)

Because of this setback, I contacted the SimFlow team, asking for a student trial to finish the simulation. However, unfortunately, they did not replay, halting my progress on the simulation.

In the future if I were to continue this project, I would definitely try some more CFD simulations!

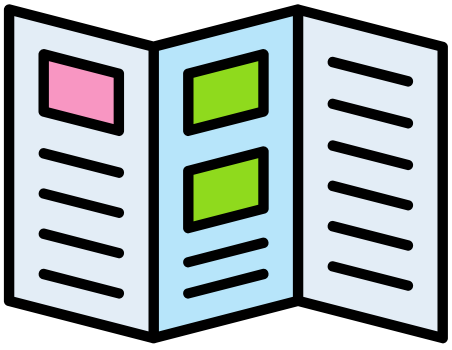
# February 2025

# Week 1

During this month, I planned, and designed my trifold.

I printed out all the images, and paragraphs needed for my tri-fold.

I put together my trifold.



# March 2025

# Week 1

Final preparations, including getting presentation, log book, document all ready and finalized.