Caster lab

MTF236 – Road Vehicle Aerodynamics

Edited 2021-01-18

What is Caster?

From Casters webpage[1],

> At Chalmers, we strive to educate engineers with great understanding of technology. Based at the Mechanical Engineering Programme, Caster aim to find ways in which we can develop this vision. We believe that the best engineers are the ones who understand the practical applications of the theory taught in class. Therefore, we continuously work to find ways in which we can combine the two in the most exciting way possible.
>
> In our facility you'll find a lounge where upcoming engineers can meet and share ideas. You'll also find a number of computers which can be used for technical development or course work. However, maybe most notable, we also have a driving simulator. By using this machine, we allow students to become users of their design, linking engineering to the customer experience. You'll encounter it in a variety of course assignments, theses or simply as part of one of our spare time projects. Come by and visit, go for a test drive and maybe, you'll be the next recruit we're looking for!

Covid-19 precautionary measures

- Do not participate in the lab if you have Covid-19 symptoms (`https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19#:~:text=symptoms`). You will be provided test data enabling you to carry out the assignment.
- Only attend your own lab group's time slot and keep distance during the lab session.
- Use the hand disinfection and face masks provided at the lab session.
- The Caster personnel will disinfect the simulator between each session.

Task

During this lab session you will drive a high performance vehicle on a figure eight track with and without an aero package. The track and the respective measurements are illustrated in Figure 1.

[1] `http://www.casterchalmers.se/`

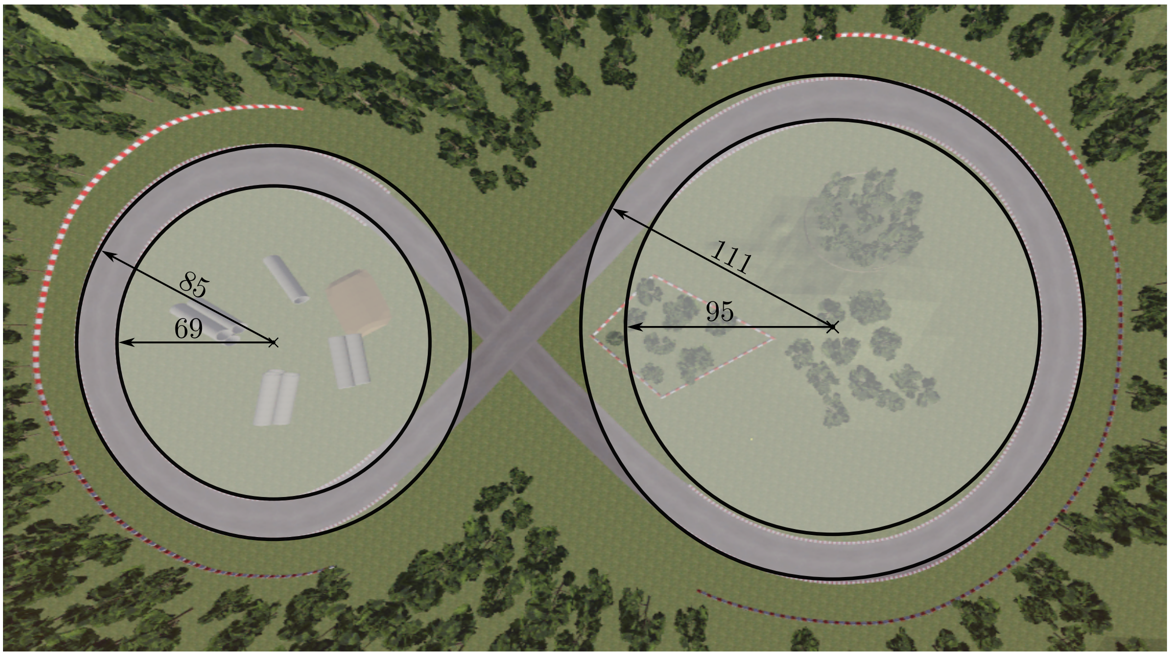

Figure 1: Track layout [m]

The purpose of this lab is to increase your understanding of vehicle dynamics coupled with aerodynamics. You will describe how the vehicle felt with and without an aero package as well as theoretically investigate the importance of good aerodynamics on a simplified model.

1. Describe how the vehicle felt to drive with and without an areo package. Support your statements with theory and/or data from your test.

2. Compare the maximum lateral acceleration you achieved in the test with and without an aero package. Present values for both the small and the large corner. A racing vehicle is rarely in a steady state condition; however, for the sake of comparing data try to pick the maximum values as close to a steady state situation as possible. Include the velocity at which you found the maximum lateral acceleration.

3. Using the values in Table 1, calculate the theoretical maximum cornering velocity and acceleration of a point mass. Include the final equations used as well as a free body diagram. Assume the vehicle to be in steady state cornering. Use the value of $-C_LA_{fixed}$. Do the same for a lift neutral vehicle, i.e. $-C_LA = 0$, and compare the theoretical velocity and acceleration to the values you got from the test. Do this for the large corner and assume the vehicle to be in the center of the track, present the results in a table. Comment on any differences and/or unexpected results.

4. Do three plots with varying $-C_LA$ on the x-axis and solve for μ, V and m on the y-axis. While plotting one, keep all other parameters constant (note: for constant velocity, use the theoretical maximum velocity with an aero package) and vary $-C_LA$ between $-C_LA_{min}$ and $-C_LA_{max}$, see Table 1. Comment on the importance of downforce in relation to tyre friction and vehicle mass. Which trade-offs would be reasonable? Why? Comment on the shape of each plot. Include the final equations used for each plot in the report.

5. You are asked by a racing enthusiast if it's worth to add 7kg to their vehicle by increasing the size of the front splitter and rear wing. Your answer is of course "*That depends on how much performance you gain*". Calculate the minimum increase of $-C_LA$ that the modifications need to give in order to offset the added weight penalty. Use the previous assumptions and values in Table 1. Assume that all other aspects of the vehicle remain the same.

6. A racing track is comprised of many turns and different cornering radii, plot the theoretical maximum velocity on the y-axis for varying corner radius on the x-axis. Vary the radius from $50m$ to $300m$, use the previous assumptions and values in Table 1, use $-C_L A_{fixed}$. Do the same for an otherwise identical vehicle with $-C_L A = 0.4$ and plot it in the same figure. How do the vehicles compare? Where are the largest difference found and why?

Table 1: Case data

Property	Value
Vehicle weight	1300 $[kg]$
μ tyre	1.5 [-]
ρ air	1.205 $[kg/m^3]$
Corner radius	103 $[m]$
$-C_L A_{fixed}$	4 $[m^2]$
$-C_L A_{min}$	-0.4 $[m^2]$
$-C_L A_{max}$	6 $[m^2]$

Report

The report should be no longer than three pages and include good figures. Good figures include, but is not limited to: readable axis, suitable font size, correct axis labels with units, high resolution images, citations in the text, legible legends and descriptive captions. Additionally all code used to solve the problems and generate the figures should be appended in the end of the report as text, i.e. no screenshots. The code should not be considered in the page count.

The complete report must be uploaded to Canvas no later than **23:59** on the **14$^{\text{th}}$ of February**. URKUND will be used to check the report (including the code) for plagiarism. The report on this deadline is graded as complete/incomplete/fail. The opportunity to re-submit the assignment (if graded incomplete) will only be allowed twice.

Good luck and have fun!