

Major Project Questions

Project Title: An Investigation into the Characteristics of Dampers and Their Effect on Vehicle Handling

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Question 1

Could you summarise, based on your findings, how each of the following damper setup options affect vehicle performance and their relative significance.

- Low Speed Bump
- Low Speed Rebound
- High Speed Bump
- High Speed Rebound

Question 1 Response (maximum 200 words)

Low speed bump controls the damping of the un-sprung mass of the vehicle, with the force v velocity graphs created for the double lane change manoeuvre the knee point is at 70 mm/s. Low speed for these dampers would be from 0 – 70 mm/s (Kasprzak, 2020). When adjusting the low speed bump in the double lane change manoeuvre figures 32 and 34 show that when bump is stiffer than rebound, the vehicle oversteers more than it understeers.

Low speed rebound damps the motion of the sprung mass under speeds of 70 mm/s, the same as the bump knee point. When the low speed rebound is stiffer than low speed bump, the vehicle will oversteer more than it will understeer opposite to when bump is stiffer. The vehicle experiences more lateral acceleration too, meaning it is utilising more of the tyre's ability indicating that it has less capability of speed through the test.

High speed bump controls the compression of the damper at high velocities, when hitting a kerb or pothole. High speed rebound controls the speed of the wheel when returning from high speed compression which will be circuit irregularities. The high-speed adjustments can determine whether the wheel will oscillate after hitting a kerb and if so, will decrease the grip on that wheel by not optimizing the tyre contact patch (Kasprzak, 2020) (Suspension Secrets, 2017).

Kasprzak, J., 2020. *FAQ*. [Online]

Available at: <https://www.kaztechnologies.com/faq/>

Suspensionsecrets, 2019. *How to remove Understeer and Oversteer*. [Online]

Available at: <https://suspensionsecrets.co.uk/how-to-remove-oversteer-and-understeer/>

[Accessed 31 03 2020].

Question 2

Given your initial analysis related to the MCR Sports 2000 vehicle, why did you choose to use the GP2 vehicle model for your simulated tests, given this vehicle has added complexities of its suspension system. Could you also outline the added complexities of the GP2 Vehicles suspension?

Question 2 Response (maximum 200 words)

The first test of the MCR was completed on the Automobilista program and the ISO double lane change manoeuvre was completed on RFactor program. This was done as advice from previous students was that RFactor is the easiest solution for downloading home-made tracks built on Bob's Track Builder Pro. After some thought and discussion with staff and students that had experience with the MCR on both softwares, the decision was made to use the GP2 car because of the MCR being a 'hybrid' model developed by different students over the years, not that it wasn't true to the real life car but because of the history being unknown.

The complexities of the GP2 car compared to the MCR is that the real-life version is equipped with 4-way Koni dampers on the rear which allow for both high and low speed adjustment (Petric, 2018) (RacecarEngineering.com, 2020). Both vehicles have the same suspension system which is the double wishbone and pushrod setup but due to the dampers being 4-way adjustable, the project led to investigate this vehicle due to it being more realistic than the 2-way dampers on the MCR.

Darjan Petric, Technical Specification, MaxF1.net (23/01/2018)

RacecarEngineering.com, Dallara GP2 Specifications (2011), (Racecarengineering.com, 2020)

Question 3

Your testing has investigated 11 setup variations. What controls did you have in place to ensure the testing was repeatable and that the driver input effect on the results is minimised so that the damper influence could be effectively isolated?

Question 3 Response (maximum 200 words)

The approach to ensure fairness in all tests was to ensure that the driver was very well drilled and informed before the first setup could be investigated. This consisted of the driver doing multiple different tests on the skid-pad to get used to the response of the vehicle and then do the double lane change manoeuvre, once confident. Each setup was tested 10 times and after each setup was tested the data was analysed by the driver to detect any irregularities or defects in the results. On top of this, every test was conducted on the same day to make sure nothing had changed such as the steering and pedal positions which could massively effect driver performance. To decrease the chances of fatigue or boredom of the tests another student was appointed to read and log the data along with the driver, both comparing and discussing what could be done better or what was not needed etc. This helped by making the tests slightly less repetitive and more exciting.

Question 4

On both your real and simulated data your histograms show a different bias on the left and right of the car, one to bump, the other to rebound. Could the left - right opposite bump/rebound bias be due to the circuit influenced? Could the number of corners have an effect?

Question 4 Response (maximum 200 words)

The circuit can have a very big impact on the histograms and the difference between both real life and simulator data sets. Inaccuracies in the circuit would influence the high-speed regions as the real-life circuit could have slightly more bumps or holes in which the simulator doesn't replicate. This would then cause the real-life data to have more high-speed damping due to more road irregularities or vice versa.

If the circuit consisted of more right-hand corners than left then the inside wheel of the car should be spending more time in rebound than the outside, as it compresses/extends through the corner. The number of corners would also influence the histograms because the more corners there are the more inputs the driver must make, resulting in the dampers spending a higher percentage of time away from the zero position. Therefore, dampers need to be adapted to the circuit, weather and driver preferences due to the differences the minor changes can make to the handling and control of the car (Kasprzak, 2020).

Kasprzak, J., 2020. *FAQ*. [Online]

Available at: <https://www.kaztechnologies.com/faq/>

Question 5

Setups 7, 8 and 9 show digressive and actually reducing coefficients of damping with increasing velocity in the high speed region. In practice how could this be achieved with a physical damper and what would the effects on vehicle behaviour be?

Question 5 Response (maximum 200 words)

Digressive dampers are fitted with different pistons than linear and progressive dampers. The digressive piston exhibits low flow rates at lower speeds creating high resistance and control. When the shaft speeds up from the knee point the force blows off gradually, allowing for less harshness than linear dampers when hitting bumps and kerbs. This is achieved by having preloaded valve disks which allow more flow at higher speeds, reducing the resistance of the oil (Fortune-auto.com, 2020) (Ryan, 2017).

Eckhardt (2004) suggests that the digressive damper has more control when driving due to the low speed damping of the vehicle being stiff. This enhances cornering ability and decreases the pitch and roll of the vehicle, making it better out on track (Eckhardt, 2004). At high speed damping digressive dampers can be good by being very active and compliant over bumps and road irregularities (Shock-surplus.com, 2020). In contrast, Ryan (2017) states that the digressive damper may blow off too much resistance and not be able to raise the chassis over high speed bumps, oscillating the wheel and feel as if the car is out of control (Ryan, 2014).

Eckhardt, R., 2004. *Shock absorber tech*. [Online]

Available at: <https://www.hotrod.com/articles/shock-dampener-overview-tech/>

[Accessed 20 05 2020].

Fortune-auto, 2020. *Hand built suspension*. [Online]

Available at: <https://fortune-auto.com/technology/#>

[Accessed 20 05 2020].

Ryan, 2014. *AccuTune*. [Online]

Available at: <https://accutuneoffroad.com/articles/digressive-vs-linear-vs-progressive-pistons-shock-valving/>
[Accessed 20 05 2020].

Shocksurplus, 2020. *What are digressive rate pistons?*. [Online]

Available at: <https://www.shocksurplus.com/pages/what-are-digressive-rate-pistons>
[Accessed 27 03 2020].

