

Major Project Questions

Project Title: An investigation into the characteristics of bump steer and how these can be altered/reduced through the evaluation of suspension kinematics to enhance the handling of a race car.

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Question 1

It is clear the Covid-19 did have an effect on your project and that certain testing aspects could not take place. Do you feel that you were at the point you should have been when the university workshops closed in March? Had you kept to your original timescale for the project? If not what aspects of the project had taken longer than planned and why?

Question 1 Response (maximum 200 words)

A timescale for the project was created at the start of the project. Data was collected for the deadline of December 2019 set out at the start of the project. A review of timescales was done throughout the project with discussion with project supervisor. The deadline for proposed improvement and track testing were moved to March and Track testing to start of April. The main reason for changing the timescale was to balance the work needed to be completed along other university assessment work ongoing at the same time. Proposed improvement were finished in March however a final static-bumpsteer test planned for the end of March could not be completed due to pandemic and University workshop closures. The start of April was chosen for track testing was due to two days needed for set-up of the car and a day for testing, and being only time where the track use with the driver was available whilst being in the Easter break to avoid time taken away from university lectures. However due to Covid-19 national lockdown the testing facility was closed before the set date for testing, I evaluated organising an earlier date or venue but due to the short notice of the closure nothing was found.

Question 2

In your testing methodology, you mention the constant radius test and how the steering wheel would be at a constant steering angle. What would be the ideal angle and how would you aim to best maintain this for each step up?

Question 2 Response (maximum 200 words)

In my methodology I mention holding the vehicle at a slow speed at a constant steering angle to maintain the radius of 50m, here the driver will maintain a fixed steering angle which allows them to travel round a 50m radius. This was to gain Ackerman data from the steering wheel position angle which would be used for creating math channels in AIM race studio. The test proposed was a constant radius steady-state as defined by ISO-4138, this test requires the vehicle to constantly travel round a 50M radius which is the constant variable in the test, the speed is increased throughout the test which is the varied variable, and the steering angle is predicted to change with change in slip angle, this is the measured variable recorded by the steering wheel angle sensor in the AIM Solo 2 DL. This is discussed in the Results and Analysis section where it describes detail of how change of steering wheel input/angle represents change in the vehicle's slip angle showing understeer, neutral-steer, or oversteer.

Question 3

In your discussion, you compare the results you measured for bump steer of the current design against those calculated in WinGeo. You mention they are not exactly the same but show a similar trend and so can be considered accurate. What was the percentage difference between the two sets of results? Why did you think they were close enough? What do you think lead to the differences?

Question 3 Response (maximum 200 words)

Bump				WinGeo	Steer_R	% Difference
Ride Height	DTI A	DTI B	Toe Steer (mm)	Ride	Toe Steer (mm)	Hundredth of a mm
197	3.5	2.85	1.233	-50	1.266	2.61
202	3.1	2.56	1.024	-45	1.028	0.39
207	2.75	2.29	0.873	-40	0.816	6.99
212	2.32	1.98	0.645	-35	0.632	2.06
217	2.13	1.88	0.474	-30	0.472	0.42
222	1.52	1.36	0.304	-25	0.337	9.79
227	1.48	1.36	0.228	-20	0.225	1.33
232	1.08	0.98	0.190	-15	0.136	39.71
237	0.5	0.45	0.095	-10	0.07	35.71
242	0.05	0.03	0.038	-5	0.025	52
247	0	0	0.000	0	0	0
252	0.08	0.08	0.000	5	-0.004	-10
257	0.31	0.3	0.019	10	0.011	7.27
262	0.68	0.65	0.057	15	0.045	26.67
267	0.98	0.93	0.095	20	0.097	2.06
272	1.28	1.19	0.171	25	0.167	2.4
277	1.6	1.46	0.266	30	0.255	4.31
282	1.8	1.6	0.379	35	0.359	5.57
287	2	1.75	0.474	40	0.479	1.04
292	2.3	1.95	0.664	45	0.616	7.79
297	2.75	2.29	0.873	50	0.768	136.7

Table 1 - Toe Steer of Standard Suspension from Bumpsteer Measuring Experiment and WinGeo

In the table above it shows the results of bumpsteer measured from the standard suspension assembly and the results of the standard suspension bumpsteer values calculated in WinGeo. The percentage difference in the results to a hundredth of a millimeter can be seen on the right-hand side of the table. For accuracy of bumpsteer measurement it was only necessary to measure to a tenth of a mm but for accuracy results, results were measure to the thousands of mm to show smaller changes. Only one result has a change of tenth of a mm which is at 50mm of ride height where 13.67 difference this results could be because of a anomaly from measuring, however every other result from the WinGeo is 100% to a tenth of a mm and only 5 values be larger than 10% change in hundredths of a mm. For accuracy and validation of the WinGeo results were 100% accurate to a tenth of a millimeter except for one result therefore the results were perceived to be accurate to an acceptable percentage for using the results calculated from the software. The differences in hundredths and thousands of a mm could be a result of two items both which were recorded by an individual and this could lead to human error. First the suspension coordinates were measured to the millimeter so this could explain why there is a small variation in the precise results of bumpsteer generated by WinGeo. Secondary the bumpsteer test was measured in thousandths of an inch then converted to mm, as 1 thousandth of a inch is equal to 0.0254mm therefore the accuracy from recording in thousandths of a inch could have a small variation in hundredths of a mm.

Question 4

In section 4.5.1, you state that track testing was predicted to show an improvement. What supporting evidence did you have for this? You discuss how along with lap time; you would also use driver feedback to gauge the success of the changes. Are there any implications of changing the suspension that might have an effect on the feedback received from the driver and how would you have determined the importance of different handling implications?

Question 4 Response (maximum 200 words)

Bumpsteer will induces straight line darting instability and uncertainly in corner feeling. Reducing bumpsteer on a race car will help maximise the controllability of the car by the driver, as there are unwanted steering variation independent to the driver. Therefore, and it was predicted there would be improvement during track testing, are the new set showed a large reduction in bumpsteer. Therefore, the Mx5 race car should have been more stable, precise, and predictable which should have allowed the driver to carry more speed through corners and spend less time making steering corrections reducing a lap time. (Roberts, 2013),(Staniforth, 2006)

The changes of suspensions set-ups were just to alter arm length or position to alter the bumpsteer produced, however the camber and toe would be set the same for all tests to maintain constancy. The different set-up may have altered whether the car understeered, neutral-steered, or oversteered in either corner entry, mid-corner, or corner exit. Nigel Greensall who was chosen for testing because he has been a professional racing driver for over 30 years, therefore his feedback would have been very detailed and representative of whether there were issues or improvements of the cars handling. The test plan has a matrix for recording corner data for understeer, neutral-steer, or oversteer this would mean a clear understanding of how the car was cornering in fast and slow corners. The data would have been used to measure corner entry and exit speed to see which set-up allows the biggest gain in maintaining speed.

Question 5

You defined how forces influences vehicle motion and how changes will affect vehicle behaviour from the rear perspective. Can you quantify any specific figures of those forces that would be acting on the wheel under cornering and by making your modification to the rear would it have an influence on the front suspension?

Question 5 Response (maximum 200 words)

The cornering force is are the forces acting on the wheel whilst corning, lateral load transfer occurs due to the shift of mass across the wheels due to centrifugal force and lateral acceleration. Corning forces created by the tyres results in lateral acceleration, the lateral acceleration which the race car can corner at changes the centrifugal forces the car experiences, these can be calculated. For a right-hand corner of 0.9 g-force lateral acceleration the left and right wheel forces were calculated.

Right Wheel Percentage Mass = 51.8%

Left Wheel Percentage Mass = 48.2%

Lateral Load Transfer = 11.64 %

Rear Centrifugal Force = -493.2 N

Right Wheel Force = -198.1 N

Left Wheel Force = -295.1 N

The maximum centrifugal force which the car can achieve on a tyre is dependent on the adhesion between the tyre and track surface. Maximising the contact patch or minimising the steer movement of the tyre input of a tyre will help improve the adhesion of tyre to the track. Minimising bumpsteer at the rear will increase the maximum lateral acceleration which the rear tyre can achieve. However, if this is larger than the front tyre then it may induce understeer as the slip angle of the front tyres is greater than the rear. An ideal set-up would have the same slip angle for both the front and rear tyre creating a car which neutral steers around a corner. This is quite difficult to perfect in a race car where the vehicle is constantly trying to corner at the speed where the tyre experience their maximum corning force without the tyres sliding sideways increasing the slip angle. Therefore, testing was to show which set up allowed for the largest cornering force and when slip angle was increased of the front or rear tyres it was controllable by the driver.

(Tanner, 2010)_(Neilson, 1968)_(Suspension Secrets, 2018)_(Suspension Secrets, 2018)_(Santos, 2015)
(Santos, 2014)