Semester Championship Documentation

Vehicle Mechanics Fundamentals

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1. General

1.1. My goal

First, let me explain the strategy chosen. I have decided that I don't want to tune the car for a specific type of track and win those races, but I want to achieve an average best setting for all tracks. Thus, when optimizing the car, I always aimed to minimize the total lap time for all tracks.

1.2. Tools

I have recorded the actual parameters and costs in tabular form to keep track of the results. Including simulated lap times, improvement rates, total lap times, total improvement, and deviation of improvements for each track. The table contains brief information on changes, conclusions, and decisions for the current setting. In the first phase of setting up the car, I used only this to narrow down the range of settings to those that were probably optimal.

1.3. Development stages

In the first phase, I wanted to find an initial setup where all costs are used for one component. From this setting, I can think backwards to develop the setting further. In the next phase, I have logically combined the parameters in proportion to the improvements in the initial settings, further narrowing the range of possible good settings. Once I had narrowed down the possible settings and got an idea of the impact of the parameters, in the third phase I used the corresponding Optimum Lap diagrams to investigate the effects of the changes, make decisions and find the best setting.

1.4. Development cost table

Development cost table		Step		Cost	Default
		step unit	dimension	$/step	value
Tire Data					
	Longitudinal Friction	0.005	-	10.00 M	2.100
	Lateral Friction	0.005	-	20.00 M	1.950
Aero Data					
	Aero Efficiency	0.010	-	5.00 M	2.000
Scaling factors					
	Power factor	0.100	%	1.18 M	100.000
General					
	Weight	0.500	kg	1.20 M	743.000
The available budget for the team is				100.00 M	

2. First development stage

0	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.0000	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
0.00 s	Power factor	0	100.000	0.00 M	87.48 s	91.39 s	76.59 s	71.37 s	68.18 s	69.39 s	83.59 s	81.02 s	72.85 s	101.38 s	64.16 s	86.09 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
953.49 s			**sum**	**0.00 M**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**update**
			remaining	**100.00 M**													
	This is the base car.				All of the budget is remaining to be spent.						Spending the whole budget on one factor, and then working backwards from there. Have to find which aspect to max out.						**comment**

1	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.4167	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-11.10 s	**Power factor**	84	**108.400**	99.12 M	86.48 s	90.46 s	75.87 s	71.38 s	67.21 s	68.55 s	82.22 s	80.09 s	72.25 s	99.68 s	63.30 s	84.90 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.39 s			**sum**	**99.12 M**	-1.00 s	-0.93 s	-0.72 s	0.01 s	-0.97 s	-0.84 s	-1.37 s	-0.93 s	-0.60 s	-1.70 s	-0.86 s	-1.19 s	**update**
			remaining	**0.88 M**													
	Increasing the engine power to the maximum to get initial setup.				Performs better on almost every track.						For now, this is the best initial setup to work backwards from.						**comment**

2	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.2353	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-10.35 s	Power factor	0	**100.000**	0.00 M	86.53 s	90.33 s	75.71 s	71.07 s	67.55 s	68.72 s	82.74 s	79.99 s	71.84 s	100.42 s	63.32 s	84.92 s	**laptime**
Σ laptime	**Weight**	83	**701.500**	99.60 M													
943.14 s			**sum**	**99.60 M**	-0.95 s	-1.06 s	-0.88 s	-0.30 s	-0.63 s	-0.67 s	-0.85 s	-1.03 s	-1.01 s	-0.96 s	-0.84 s	-1.17 s	**update**
			remaining	**0.40 M**													
	Decreasing the weight to the minimum to get initial setup.				Maximizing engine power performs better overall.						Not changing the initial setup to this.						**comment**

3	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.4165	Lateral Friction	0	1.950	0.00 M													
Aero Efficiency	**Aero Efficiency**	20	**2.200**	100.00 M													
Σ update	Power factor	0	100.000	0.00 M	86.51 s	90.44 s	75.79 s	71.35 s	67.23 s	68.60 s	82.17 s	80.13 s	72.21 s	99.65 s	63.38 s	84.93 s	**laptime**
-11.10 s	Weight	0	**743.000**	0.00 M													
Σ laptime			sum	100.00 M	-0.97 s	-0.95 s	-0.80 s	-0.02 s	-0.95 s	-0.79 s	-1.42 s	-0.89 s	-0.64 s	-1.73 s	-0.78 s	-1.16 s	**update**
942.39 s			remaining	0.00 M													
	Increasing the aero efficiency to the maximum to get initial setup.				Overall it performs the same as maximizing the engine power, but the devation of the updates per track is smaller.						Even though the deviation is smaller not changing the initial setup to this, as engine power is more understandable from the get go.						**comment**

4	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.1355	**Lateral Friction**	5	**1.975**	100.00 M													
Σ update	Aero Efficiency	0	**2.000**	0.00 M													
-4.59 s	Power factor	0	100.000	0.00 M	87.13 s	90.85 s	76.14 s	71.32 s	67.91 s	69.09 s	83.21 s	80.54 s	72.36 s	100.95 s	63.82 s	85.58 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
948.90 s			sum	100.00 M	-0.35 s	-0.54 s	-0.45 s	-0.05 s	-0.27 s	-0.30 s	-0.38 s	-0.48 s	-0.49 s	-0.43 s	-0.34 s	-0.51 s	**update**
			remaining	0.00 M													
	Increasing the lateral friction to the maximum to get initial setup.				Performs worse than the above 3 factors.						Not changing the initial setup to this.						**comment**

5	Development	Step	Value	Cost	Track												
deviation	**Longitudinal Friction**	10	**2.150**	100.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorcham*	*Red Bull Ring*	*Suzuka International Racing*	
0.0779	Lateral Friction	0	**1.950**	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-2.22 s	Power factor	0	100.000	0.00 M	87.23 s	91.12 s	76.34 s	71.40 s	67.98 s	69.19 s	83.43 s	80.82 s	72.63 s	101.19 s	64.02 s	85.92 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
951.27 s			sum	100.00 M	-0.25 s	-0.27 s	-0.25 s	0.03 s	-0.20 s	-0.20 s	-0.16 s	-0.20 s	-0.22 s	-0.19 s	-0.14 s	-0.17 s	**update**
			remaining	0.00 M													
	Increasing the longitudinal friction to the maximum to get initial setup.				Performs way worse than the every other factor.						Not changing the initial setup to this.						**comment**

3. Second development stage

0	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.0000	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
0.00 s	Power factor	0	100.000	0.00 M	87.48 s	91.39 s	76.59 s	71.37 s	68.18 s	69.39 s	83.59 s	81.02 s	72.85 s	101.38 s	64.16 s	86.09 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
953.49 s			**sum**	**0.00 M**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**update**
			remaining	**100.00 M**													
	This is the base car.				All of the budget is remaining to be spent.						Spending the whole budget on one factor, and then working backwards from there. Have to find which aspect to max out.						**comment**

1	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.4167	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	0	2.000	0.00 M													
-11.10 s	Power factor	84	**108.400**	99.12 M	86.48 s	90.46 s	75.87 s	71.38 s	67.21 s	68.55 s	82.22 s	80.09 s	72.25 s	99.68 s	63.30 s	84.90 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.39 s			**sum**	**99.12 M**	-1.00 s	-0.93 s	-0.72 s	0.01 s	-0.97 s	-0.84 s	-1.37 s	-0.93 s	-0.60 s	-1.70 s	-0.86 s	-1.19 s	**update**
			remaining	**0.88 M**													
	Increasing the engine power to the maximum to get initial setup.				Performs better on almost every track.						This will be the initial setup.						**comment**

2	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.0259	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	10	**2.100**	50.00 M													
-0.36 s	Power factor	42	**104.200**	49.56 M	86.47 s	90.42 s	75.80 s	71.35 s	67.19 s	68.55 s	82.16 s	80.08 s	72.20 s	99.62 s	63.31 s	84.88 s	**laptime**
Σ laptime	Weight	0	743.000	0.00 M													
942.03 s			**sum**	**99.56 M**	-0.01 s	-0.04 s	-0.07 s	-0.03 s	-0.02 s	0.00 s	-0.06 s	-0.01 s	-0.05 s	-0.06 s	0.01 s	-0.02 s	**update**
			remaining	**0.44 M**													
	When choosing the initial setup, the Aero Efficiency and Power Factor had a very similar performance increase. Spending half of the budget on one and the other.				Performs slightly better almost on every track.						This is a better result, keeping this iteration.						**comment**

3	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	0	2.100	0.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.1026	Lateral Friction	0	1.950	0.00 M													
Σ update	Aero Efficiency	7	**2.070**	35.00 M													
0.21 s	Power factor	28	**102.800**	33.04 M	86.46 s	90.38 s	75.73 s	71.26 s	67.30 s	68.60 s	82.32 s	80.05 s	72.09 s	99.85 s	63.31 s	84.89 s	**laptime**
Σ laptime	Weight	26	**730.000**	31.20 M													
942.24 s			**sum**	**99.24 M**	-0.02 s	-0.08 s	-0.14 s	-0.12 s	0.09 s	0.05 s	0.10 s	-0.04 s	-0.16 s	0.17 s	0.01 s	-0.01 s	**update**
			remaining	**0.76 M**													
	Combining the three top performers of the initial setup change based on their performance increase.				Performs worse overall.						Not keeping this iteration.						**comment**

4	Development	Step	Value	Cost	Track												
deviation	Longitudinal Friction	1	**2.105**	10.00 M	*Sepang International Circuit*	*Shanghai International Circuit*	*Circuit de Catalunya*	*Circuit de Monaco*	*Circuit de Nevers Magny-Cours*	*Circuit Gilles Villeneuve*	*Silverstone Circuit*	*Nürburgring*	*Hungaroring*	*Circuit de Spa-Francorchamps*	*Red Bull Ring*	*Suzuka International Racing Course*	
0.1868	Lateral Friction	1	**1.955**	20.00 M													
Σ update	Aero Efficiency	4	**2.040**	20.00 M													
2.31 s	Power factor	20	**102.000**	23.60 M	86.66 s	90.55 s	75.87 s	71.29 s	67.50 s	68.76 s	82.64 s	80.23 s	72.19 s	100.23 s	63.49 s	85.14 s	**laptime**
Σ laptime	Weight	22	**732.000**	26.40 M													
944.55 s			**sum**	**100.00 M**	0.18 s	0.09 s	0.00 s	-0.09 s	0.29 s	0.21 s	0.42 s	0.14 s	-0.06 s	0.55 s	0.19 s	0.24 s	**update**
			remaining	**0.00 M**													
	Combining all of the parameters of the initial setup change based on their performance increase.				Performs even worse then the previous iteration.						Changing the friction coefficients might not be a viable option. Very high cost, very low impact.						**comment**

4. Third development stage