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Chapter 1

Introduction

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1.1 System Description

The properties of the bodies are given in Tables 1.1 and 1.2. The properties of the connecctions are given in Tables 1.3, 1.4, and 1.5.

Table 1.1: Body CG Locations and Mass

No.	Body Name	Location [m]	Mass [kg]
1	bike	0.678, 0.000, 0.472	165.130
2	upper body	0.415, 0.000, 1.140	33.680
3	upper fork	1.164, 0.000, 0.770	9.990
4	lower fork	1.365, 0.000, 0.324	7.250
5	swing arm	0.196, 0.000, 0.311	8.000
6	bell crank	0.493, 0.000, 0.173	0.000
7	front wheel, bike	1.410, 0.000, 0.282	11.900
8	rear wheel, bike	0.000, 0.000, 0.297	14.700

Table 1.2: Body Inertia Properties

No.	Body Name	Inertia [kg·m^2] (I_{xx}, I_{yy}, I_{zz}; I_{xy}, I_{yz}, I_{zx})
1	bike	11.085, 22.013, 14.982; 0.000, 0.000, 3.691
2	upper body	1.428, 1.347, 0.916; 0.000, 0.000, −0.443
3	upper fork	1.341, 1.548, 0.413; 0.000, 0.000, 0.000
4	lower fork	0.000, 0.000, 0.000; 0.000, 0.000, 0.000
5	swing arm	0.020, 0.259, 0.259; 0.000, 0.000, 0.000
6	bell crank	0.000, 0.000, 0.000; 0.000, 0.000, 0.000
7	front wheel, bike	0.270, 0.484, 0.270; 0.000, 0.000, 0.000
8	rear wheel, bike	0.383, 0.638, 0.383; 0.000, 0.000, 0.000

Note: inertias are defined as the positive integral over the body, e.g., $I_{xy} = +\int r_x r_y \, dm$.

Table 1.3: Connection Location and Direction

No.	Connection Name	Location [m]	Unit Axis
1	rear axle	0.000, 0.000, 0.297	0.000, 1.000, 0.000
2	arm pivot	0.549, 0.000, 0.361	0.000, 1.000, 0.000
3	bell crank pivot	0.539, 0.000, 0.188	0.000, 1.000, 0.000
4	rider	0.364, 0.000, 0.844	0.000, 1.000, 0.000
5	steering head	1.173, 0.000, 0.749	0.407, 0.000, −0.914
6	front axle	1.410, 0.000, 0.282	0.000, 1.000, 0.000
7	fork joint	1.342, 0.000, 0.426	−0.427, 0.000, 0.904
8	front tire lateral	1.410, 0.000, 0.000	0.000, 1.000, 0.000
9	rear tire lateral	0.000, 0.000, 0.000	0.000, 1.000, 0.000
10	front tire longitudinal	1.410, 0.000, 0.000	1.000, 0.000, 0.000
11	rear tire longitudinal	0.000, 0.000, 0.000	1.000, 0.000, 0.000
12	front tire vertical	1.410, 0.000, 0.000	0.000, 0.000, 1.000
13	rear tire vertical	0.000, 0.000, 0.000	0.000, 0.000, 1.000

Table 1.4: Connection Locations

No.	Connection Name	Location [m]	Location [m]
1	rear spring	0.487, 0.000, 0.489	0.444, 0.000, 0.178
2	right front spring	1.226, −0.100, 0.671	1.396, −0.100, 0.311
3	left front spring	1.226, 0.100, 0.671	1.396, 0.100, 0.311
4	rear pull rod	0.372, 0.000, 0.275	0.495, 0.000, 0.152

Table 1.5: Connection Properties

No.	Connection Name	Stiffness [N/m]	Damping [Ns/m]
1	front tire lateral	0	40,000
2	rear tire lateral	0	40,000
3	front tire longitudinal	0	60,000
4	rear tire longitudinal	0	60,000
5	front tire vertical	130,000	0
6	rear tire vertical	141,000	0
1	rear spring	58,570	11,650
2	right front spring	12,500	1,067
3	left front spring	12,500	1,067

Chapter 2

Analysis

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2.1 Eigenvalue Plot

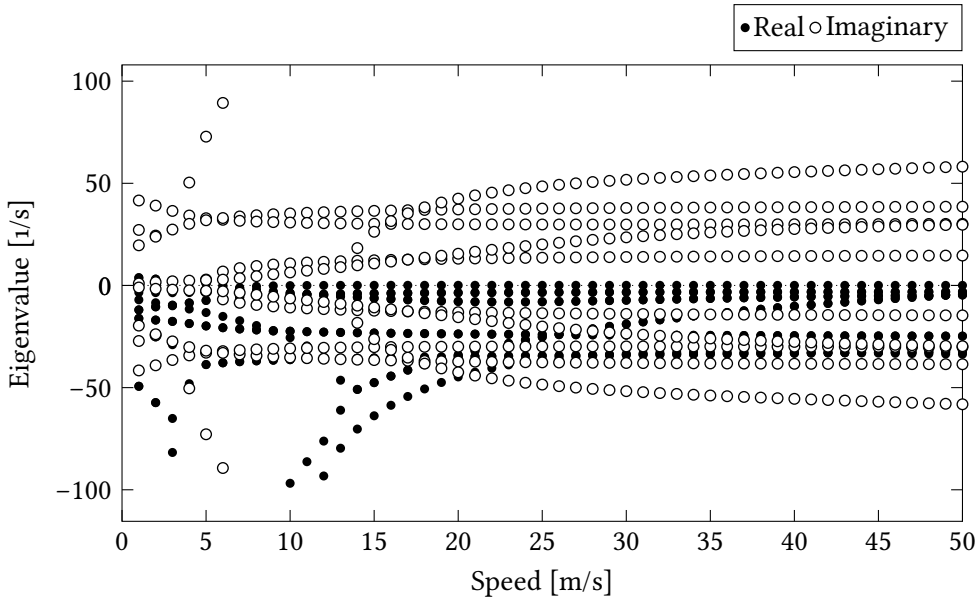

Figure 2.1: Eigenvalues vs. Speed

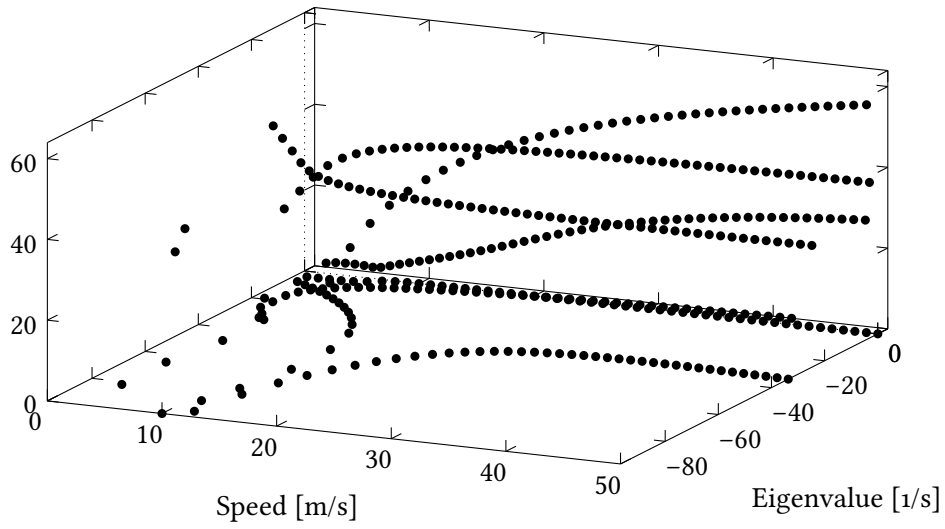

Figure 2.2: Eigenvalues vs. Speed

2.2 Frequency Response Plots

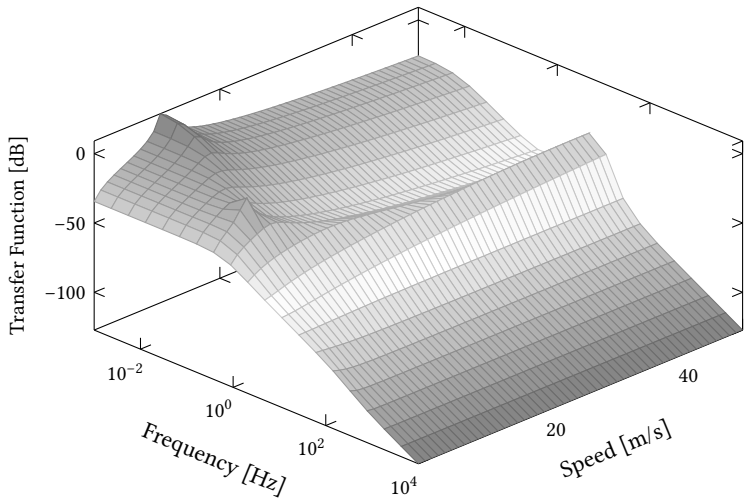

Figure 2.3: Frequency response: yaw rate/steer torque

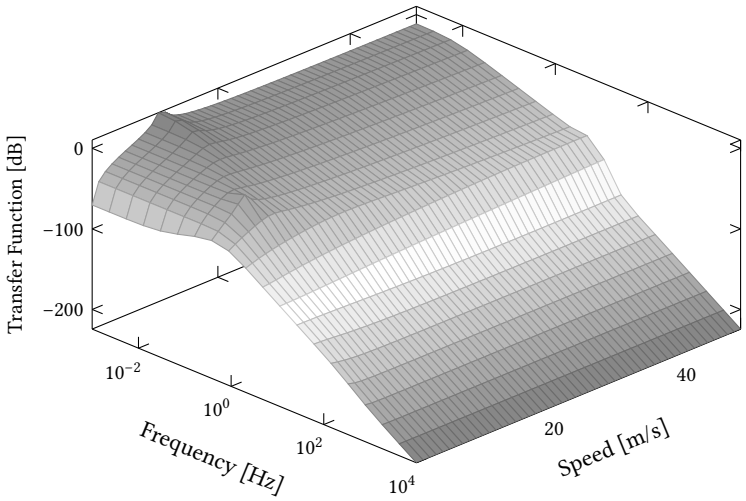

Figure 2.4: Frequency response: roll angle/steer torque

2.3 Steady State Transfer Functions Plot

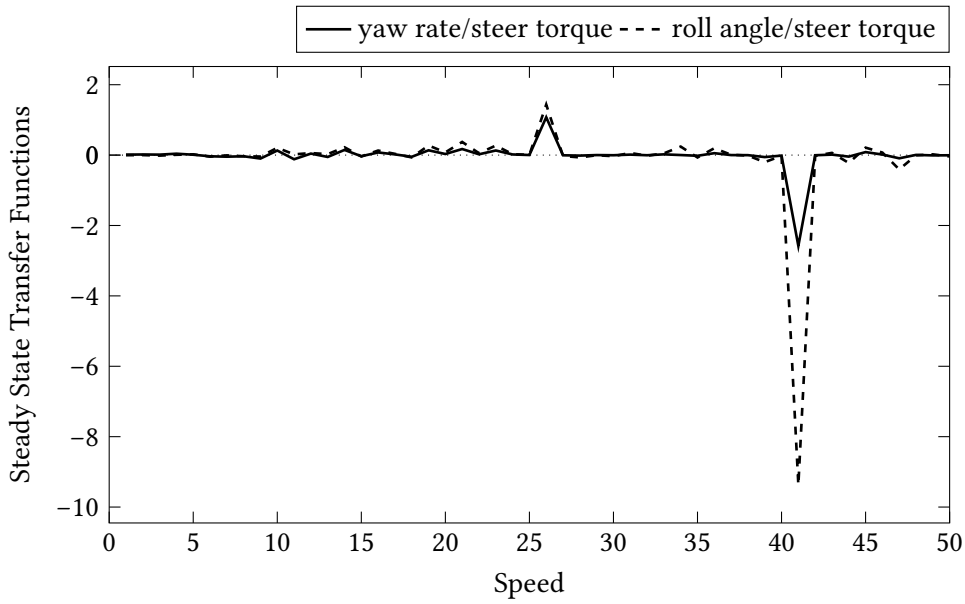

Figure 2.5: Steady State Transfer Functions

2.4 Equilibrium Analysis

The results of the equlibrium load analysis are given in Tables 2.1 and 2.2.

Table 2.1: System Static Deflections

No.	Body Name	Type	Deflection [m] or [rad]
1	bike	translation	5.9952×10^{-3}, 0.0000×10^{0} , -5.6380×10^{-2}
–	–	rotation	0.0000×10^{0} , -2.1752×10^{-2}, 0.0000×10^{0}
2	upper body	translation	-8.5266×10^{-3}, 0.0000×10^{0} , -6.2098×10^{-2}
–	–	rotation	0.0000×10^{0} , -2.1752×10^{-2}, 0.0000×10^{0}
3	upper fork	translation	-4.7826×10^{-4}, 0.0000×10^{0} , -4.5806×10^{-2}
–	–	rotation	0.0000×10^{0} , -2.1752×10^{-2}, 0.0000×10^{0}
4	lower fork	translation	-5.6905×10^{-3}, 0.0000×10^{0} , -9.8518×10^{-3}
–	–	rotation	0.0000×10^{0} , -2.1752×10^{-2}, 0.0000×10^{0}
5	swing arm	translation	3.9213×10^{-3}, 0.0000×10^{0} , -2.7082×10^{-2}
–	–	rotation	0.0000×10^{0} , 9.0939×10^{-2}, 0.0000×10^{0}
6	bell crank	translation	6.9350×10^{-3}, 0.0000×10^{0} , -4.3242×10^{-2}
–	–	rotation	0.0000×10^{0} , 3.4851×10^{-1}, 0.0000×10^{0}
7	front wheel, bike	translation	-4.7770×10^{-3}, 0.0000×10^{0} , -8.8729×10^{-3}
–	–	rotation	0.0000×10^{0} , 0.0000×10^{0} , 0.0000×10^{0}
8	rear wheel, bike	translation	2.6209×10^{-3}, 0.0000×10^{0} , -9.2581×10^{-3}
–	–	rotation	0.0000×10^{0} , 0.0000×10^{0} , 0.0000×10^{0}

Table 2.2: System Preloads

No.	Connector Name	Type	Load [N] or [Nm] (Components; Magnitude)
1	rear axle	force	0.0000×10^{0}, 0.0000×10^{0}, 1.1612×10^{3}; 1.1612×10^{3}
2	arm pivot	force	-2.3178×10^{3}, 0.0000×10^{0}, 1.2389×10^{3}; 2.6281×10^{3}
3	bell crank pivot	force	2.5910×10^{3}, 0.0000×10^{0}, -3.3410×10^{2}; 2.6125×10^{3}
4	rider	force	0.0000×10^{0}, 0.0000×10^{0}, 3.3040×10^{2}; 3.3040×10^{2}
–	–	moment	0.0000×10^{0}, -1.6850×10^{1}, 0.0000×10^{0}; 1.6850×10^{1}
5	steering head	force	0.0000×10^{0}, 0.0000×10^{0}, -8.6761×10^{2}; 8.6761×10^{2}
–	–	moment	0.0000×10^{0}, 2.3293×10^{2}, 0.0000×10^{0}; 2.3293×10^{2}
6	front axle	force	0.0000×10^{0}, 0.0000×10^{0}, 1.0367×10^{3}; 1.0367×10^{3}
7	fork joint	force	3.7284×10^{2}, 0.0000×10^{0}, 1.7607×10^{2}; 4.1232×10^{2}
–	–	moment	0.0000×10^{0}, -6.8862×10^{1}, 0.0000×10^{0}; 6.8862×10^{1}
8	front tire lateral	force	0.0000×10^{0}, 0.0000×10^{0}, 0.0000×10^{0}; 0.0000×10^{0}
9	rear tire lateral	force	0.0000×10^{0}, 0.0000×10^{0}, 0.0000×10^{0}; 0.0000×10^{0}
10	front tire longitudinal	force	0.0000×10^{0}, 0.0000×10^{0}, 0.0000×10^{0}; 0.0000×10^{0}
11	rear tire longitudinal	force	0.0000×10^{0}, 0.0000×10^{0}, 0.0000×10^{0}; 0.0000×10^{0}
12	front tire vertical	force	0.0000×10^{0}, 0.0000×10^{0}, 1.1535×10^{3}; 1.1535×10^{3}
13	rear tire vertical	force	0.0000×10^{0}, 0.0000×10^{0}, 1.3054×10^{3}; 1.3054×10^{3}
14	rear spring	force	2.7323×10^{2}, 0.0000×10^{0}, 1.9875×10^{3}; -2.0062×10^{3}
15	right front spring	force	-1.8642×10^{2}, 0.0000×10^{0}, 3.9478×10^{2}; -4.3658×10^{2}
16	left front spring	force	-1.8642×10^{2}, 0.0000×10^{0}, 3.9478×10^{2}; -4.3658×10^{2}
17	rear pull rod	force	2.3178×10^{3}, 0.0000×10^{0}, -2.3216×10^{3}; 3.2806×10^{3}

Chapter 3

Conclusion

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Appendix A

Equations of Motion