Homework for Lecture 2

1. In a set of coasting tests, there is no wind but the road has constant slope. In each test, the vehicle starts from $20\mathrm{m/s}$ and coasts down into stop in neutral gear. In total, the vehicle runs back and forth for four times. See the data in “data_A2B.mat” (containing the data when coasting from A to B) and “data_B2A.mat” (containing the data when coasting from B to A). Each file has four groups of data, and each group of data has three columns: time (s), vehicle velocity $(\mathrm{m/s})$, and longitudinal acceleration $(\mathrm{m/s^2})$. Note that the measured data is biased and noisy because of imperfect sensors. The known parameters are:

Mass	m	1240 [kg]
Frontal area	A	1.87 [$\mathrm{m^2}$]
Air density	ρ	1.2 [$\mathrm{kg/m^3}$]
Wheel radius	r	0.3 [m]
Four wheels' moment of inertia	$\sum I_w$	4.73 [$\mathrm{kg \cdot m^2}$]
Constant of gravity	g	9.8 [$\mathrm{m/s^2}$]

Please calculate the rolling resistance coefficient f, aerodynamic drag coefficient C_D, and road slope gradient i.

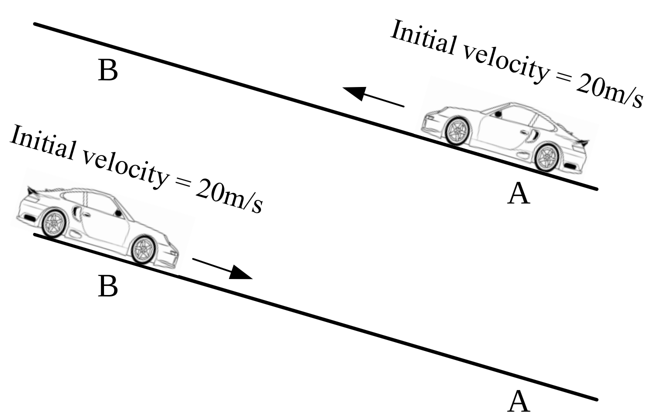

Figure 1. Sketch of vehicle coasting tests.

2. The parameters of a 2-DOF vehicle model under ISO Vehicle Coordinate System are listed as follows: mass (m): 1818 kg, moment of inertia around Z axle (I_{zz}): 3885 $\mathrm{kg}\cdot\mathrm{m}^2$; distance from front axle to gravity center (a): 1.463 m; distance from rear axle to gravity center (b): 1.585 m; front wheel cornering stiffness in total (k_1): $-62618\ \mathrm{N/rad}$; rear wheel cornering stiffness in total (k_2): $-110185\ \mathrm{N/rad}$.

(1) Please draw the step response of lateral speed and yaw rate at the vehicle speed of $20\ \mathrm{km/h}$ and $50\ \mathrm{km/h}$ with the model input being the frontal wheel angle (steering angle) δ.

(b) Please analyze the changes of the natural frequency and damping rate with respect to increasing vehicle speed, moment of inertia and front wheel cornering stiffness.

3. The sketch of a 1/4-car model is shown in the following figure. The known parameters are: sprung mass $M_s = 1250$ kg, $K_s = 44000\ \mathrm{N/m}$, $C_s = 4000\ \mathrm{kg/s}$, unsprung mass $M_u = 200$ kg, K_u=$400000\ \mathrm{N/m}$, C_u=$50\ \mathrm{kg/s}$. Please derive the transfer function from the acceleration of road excitation $\ddot{x}_r$ to the acceleration of car body $\ddot{x}_s$ based on the quarter-car model, and then demonstrates the changes of its bode graph with $\pm 10\%$ parametric variation (including M_s, K_s and C_s).

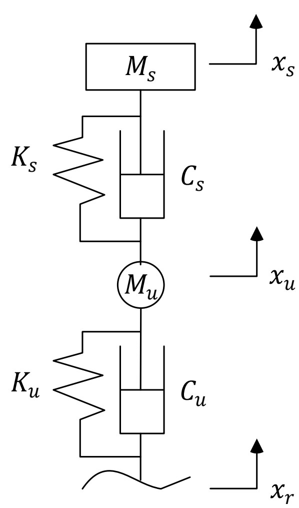

Figure 2. Sketch of a 1/4-car model.