

MECH 4420 Homework #7
(Due Monday 11/10/2025, **B#** - is Bonus, i.e. not required)

Below is data for the Infiniti G35 4-door sedan. What is the understeer gradient?

$$\begin{array}{lll} m = 1573 \text{ kg (unloaded)} & a = 1.311 \text{ m} & C_{\alpha f} = 45,000 \text{ N/rad/tire} \\ I_z = 3200 \text{ kgm}^2 & b = 1.539 \text{ m} & C_{\alpha r} = 70,000 \text{ N/rad/tire} \end{array}$$

1) In class we developed the model for slip angle and yaw rate given steer angle. Given the parameters above (for the G35), write a program to simulate the vehicle yaw rate and slip angle as a function of the steer angle and vehicle velocity.

- a) Download the **TWO** G35 data files from the web. Note that you simply calculate the front and rear tire slip angles as a function of the velocity, steer angle, slip angle and yaw rate.
- b) Provide clearly labeled plots of the simulated vs. experimental yaw rate vehicle sideslip and tire sideslip angles (two pages at the most). Simulated and experimental plots should be on the same figure (use solid for experimental and dashed for simulated with a legend).

B1) A simple non-linear tire model is the Duggoff Tire model which is described by the following equations:

$$F_y = -C_{\alpha} \tan(\alpha) f(\lambda) \quad f(\lambda) = \begin{cases} (2 - \lambda)\lambda & \text{if } \lambda < 1 \\ 1 & \text{if } \lambda \geq 1 \end{cases} \quad \lambda = \frac{\mu F_z}{2C_{\alpha} |\tan(\alpha)|}$$

- a) Plot F_y vs. α for the Duggoff Tire model. What do you notice is different that the magic tire model?
- b) Using the Duggoff Model, repeat problem #1 using a non-linear simulation. What coefficient of friction value (μ) did you use to fit the data the best?

2) Simulate the G35 performing a step steer input that provides a final yaw rate of 50 deg/s. You can use “lsim”, “step”, “dlsim”, “dstep” or your simulation for problem #1 to perform the simulation

- a) Write a formula to calculate the desired steer angle input.
- b) Simulate the Step Steer at 15 m/s (plot yaw rate and sideslip angle)
- c) Simulate the Step Steer at 30 m/s
- d) Swap the front and rear cornering stiffnesses and move the CG back 20 cm. What is the new understeer gradient? Repeat parts b and c. What happens? Why?

Turn in all 8 plots (clearly labeled) on one page (subplot(4,2,#)) and use “>>orient tall” Label the pole locations (including ω_n and ζ) for each run.

3) Repeat problem #2 using the magic tire model from HW#6 **OR** the Duggoff Tire Model (state which you use). This should be a full non-linear simulation (i.e. do not linearize the tire model). Compare the results to problem #2.

B2) Add tire relaxation length to your model and compare the eigenvalues and response to problem #2. Assume a tire relaxation length of 0.5 meters.

B3) Using your non-linear tire model generate phase plane plots for Problem #3