AuE 4600/6600 (Fall 2022) – Homework Assignment #2

Reference: Chapters 2 and 14 (Milliken, Race Car Vehicle Dynamics)
Chapters 13.1 – 13.4 (Rajamani, Vehicle Dynamics and Control)

Due Date: 09/29/2022, midnight

Problem 1 (100 points):

Raw tire data collected on a small Formula SAE racing tire at the Calspan Tire Research Facility* is provided in two files on the Canvas website. Both files contain the same data — one is in Matlab format and one is a tab-delimited .dat file. You may use either file to complete this homework.

In Matlab, use the command `load tireF15.mat` to introduce the variables to the workspace.

The tab delimited .dat file is well-suited for import into Excel. There are several ways to import the data. Opening the .dat file with Excel should work. If all the contents appear in the first column use the "Text to Columns" menu item to parse the file into individual columns.

Symbols and units used in the file are:

ET	Elapsed Time of the test, sec	FZ	Normal Load, N
V	Roadway velocity, kph	FY	Lateral Force, N
SA	Slip Angle, deg	MX	Overturning Moment, N-m
IA	Inclination Angle, deg	MZ	Aligning Torque, N-m
P	Inflation Pressure, kPa	RL	Loaded Radius, cm

The data is one run from a longer test. It has been collected during a series of slip angle sweeps at various operating conditions. Since this is "real world" data it also contains noise, target error and effects from difficult (or impossible) to control variables such as temperature, tire wear, etc.

You may wish to make the following plots to help you understand the test sequence. These should not be submitted with this homework assignment. Try: Roadway speed vs. time. Inclination angle vs. time. Slip angle vs. time. Normal Load vs. time. Inflation Pressure vs. time.

When reviewing the data, note that there are a total of six target loads, each 50 lb apart. While the data is presented in SI units, the native units for the Calspan Tire Research Facility are US Customary Units. Thus, for simplicity the test was designed around common USCS values, such as 50 lb load spacing, 25 mph, inflation pressures of 8 and 12 psi, etc. Target values will not have "round" SI values.

Homework questions appear on the next page...

*Data for this assignment was collected by the Formula SAE Tire Test Consortium at the Calspan Corporation Tire Research Facility in Buffalo, NY.

For questions 1-5, only use the data at 0 deg. Inclination Angle, 12 psi Inflation Pressure and 25 mph Roadway speed:

1. Plot Lateral Force vs. Slip Angle for each Normal Load. Plots should be similar to those on pages 76-80 of RCVD. (You may place all curves on one plot if each curve is properly identified.) Submit the plot.

2. Determine the Cornering Stiffness of the tire at each Normal Load. Put these values in a table and plot Cornering Stiffness vs. Normal Load (one plot). Submit the table and the plot.

3. Determine the Friction Coefficient of the tire at each Normal Load in a left hand turn. Put these values in a table and plot Friction Coefficient vs. Normal Load (one plot). Submit the table and the plot.

4. Plot Aligning Torque vs. Slip Angle for each Normal Load. Plots should be somewhat similar to that on page 30 of RCVD. (You may place all on one plot if each curve is properly labeled.) Submit the plot.

5. The first approximation in modeling the vertical behavior of a tire is to consider the tire simply as a spring. Determine the Vertical Spring Rate of the tire at zero Slip Angle, zero Inclination Angle and zero Lateral Force. To do this, begin by plotting Normal Load vs. Loaded Radius at this condition. The slope of this curve is the tire vertical spring rate. What is the spring rate at 200 lb Normal Load? Submit your plot and the value at 200 lb.