AuE-ME 4600-6600 (Fall 2022) – Homework Assignment #5

Reference:	See Canvas for chapters from Milliken, Dukkipati
Due Date:	11/10/22, at midnight

Problem 1 (10 pts.)

Give limits on the Understeer Gradient, so that the characteristic velocity of a vehicle with wheelbase 3.1 m will be in the desired range of 80-120 km/h. What is maximum achievable steering sensitivity in this range (yaw velocity response)? Assuming a steering gear ratio of 19, what steering wheel angle does the driver have to provide for cornering with $a_y = 5\ m/s^2$ lateral acceleration?

Problem 2 (40 pts.)

Consider the following Bicycle model vehicle:

Mass:	120slug
Wheelbase:	9 ft.
Weight Distribution:	Defined below.
Front Cornering Stiffness:	350 lb/deg
Rear Cornering Stiffness:	350 lb/deg

This vehicle is being driven on a 320 ft radius (left turn) skid pad.

For the weight distributions 60% front (a=3.6 ft, b=5.4 ft), 50% front (a=4.5 ft, b=4.5 ft), and 40% front (a=5.4 ft, b=3.6 ft), answer the following:

A. Calculate the six stability derivatives for this vehicle at a speed of 30 mph.
B. Determine the stability factor.
C. Determine the critical speed. If it does not exist, say "does not exist".
D. Determine the distance from the neutral steer point (d) to the front tire.
E. Determine the static margin.
F. Plot the theoretical vehicle stabilizing moment against velocity from 0 to 75 mph. That is, plot $N_\beta \cdot \beta + N_r \cdot r$ vs. v_x. (See hint below.)
G. Plot the vehicle control moment against the vehicle stabilizing moment for velocities from 0 to 75 mph. That is, plot $N_\delta \cdot \delta$ vs. $N_\beta \cdot \beta + N_r \cdot r$. (See hint below.)

You should plot the results for all three models in one figure for questions F and G.

Hint for part F:
Select a range of velocities from 0 to 75 mph in increments of, say, 1 mph. For each of these velocities you need to calculate theoretical values for N_β, β, N_r, and r. The theoretical β can be derived as:

$$\beta = \frac{b}{R} - \left(\frac{a * m * v^2}{l * R * C_{\alpha R}}\right)$$

Hint for part G:
Use the understeer gradient and the lateral acceleration at each velocity to find δ at each velocity.

Problem 3 Simulation (50 pts)

Vehicle Parameters:

Mass:	1637 kg
Yaw inertia:	3326 $kg - m2$
Wheelbase:	2.736 m
Weight distribution:	60% to front
Front cornering stiffness:	802 N/deg
Rear cornering stiffness:	785 N/deg
Steering ratio:	15: 1 (15 degree at the steering wheel = 1 degree at the front wheel)

Maneuver Description:

In this problem, you are required to simulate the bicycle model for the maneuver that is described below. Based on the description, you should create a vector of inputs for the simulation.

1) The roadwheel steering angle is the input to your bicycle model. In the first maneuver, provide a step input for this steering angle. The vehicle is first being driven down a straight line at 74 mph for 7 seconds after which the driver holds the handwheel position constant at 45 degrees for 60 seconds. The handwheel position is then returned to 0 degrees and the maneuver is terminated

Answer the following:

Using a state-space approach, determine the states, β and $\dot{\psi}$, of the bicycle model for the complete maneuver. Assume a linear tire model. Provide plots for each maneuver (1) β v/s time, (2) $\dot{\psi}$ v/s time, (3) α_f v/s time, and (4) α_r vs time for the entire length of the simulation. (Total 4 plots)