MECH 4420 Homework #8
(Due Monday 12/1/2024 – Extra points if turned in earlier)

Below is data for the MKZ Sedan.

m =1856 kg (unloaded)	a = 1.257 m	$C_{\alpha f}$ = 60,000 N/rad/tire
Iz = 4292 kgm^2	b = 1.593 m	$C_{\alpha r}$ = 92,300 N/rad/tire

For this assignment you can use either classical control, cascaded control, or modern control techniques (or combinations). Note that the steering controller has a 0.1 second time constant. Use the provided p-code (run_mkz.p) to simulate the vehicle.

1) Design a control system to control the vehicle yaw rate. Using the simulation of the MKZ, show that you can "track" a desired yaw rate of 50 deg/s (you may assume you have access to all the states). Plot the states and input
   a) Simulate the maneuver at 15 m/s and 30 m/s.
   b) Swap the front and rear cornering stiffnesses as well as ***a*** and ***b*** (i.e. driving in reverse). Repeat part a.

2) Simulate the MKZ doing a lane change maneuver. Use the sine function below for the steer angle input.

$$\delta(t) = DS \times \sin(2\pi \times (t - 0.5)) \qquad 0.5 \le t \le 1.5$$

$$\delta(t) = 0 \qquad 0 \le t \le 0.5 \text{ and } 1.5 \le t \le 3$$

   a) Simulate the maneuver at 15 m/s (DS=0.4) and 30 m/s (DS=0.2). Plot y for each speed on one page.
   b) Swap the front and rear cornering stiffnesses as well as ***a*** and ***b***. Repeat part a. What happens? Why?

3) Design a control system to "autonomously" perform a 4 meter lane change maneuver.
   a) Simulate the maneuver at 15 m/s and 30 m/s. Plot y for each speed on one page.
   b) Swap the front and rear cornering stiffnesses and move the CG back 20 cm. Repeat part a.

B1: Design an estimator to estimate yaw rate and sideslip given only yaw rate measurements. Compare the estimated states (yaw rate and sideslip) to the actual states.
   a) Estimate the sideslip for the simulations performed in HW#7 (problem #2)
   b) Estimated the sideslip using the experimental data from HW#7

B2: Using the non-linear Dugoff Tire Model with (μ=0.6) what is the fastest you can get the MKZ to drive through the chicane profile on the website? Alternatively, you could answer how fast you can get the MKZ to perform the lane change.

B3: Using the non-linear magic tire model from HW#5 develop a controller to simulate the MKZ performing the skid pad test for HW#5. This should allow generation of the understeer curves without having to invert the tire equations.