MECH 4420 Homework #7
(Due Thursday 12/6/2006 in class)

Below is data for a Mercedes E-class Sedan. What is the understeer gradient?

m =1640 kg	a = 1.313 m	$C_{\alpha f}$ =55,000 N/rad/tire
Iz = 3500 kgm^2	b = 1.52 m	$C_{\alpha r}$ =85,000 N/rad/tire

1) In class we developed the model for slip angle and yaw rate given steer angle. Given the parameters above (for the E-class), 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 data files from the web. Data file #1 is the vehicle velocity and steer angle recorded at 200 Hz. Data file #2 is the output measurements (r, β, α_f, α_r) measured at 10 Hz. Note that you simply calculate the front and rear tire slip angles as a function of the velocity, steer angle, and simulated slip angle and yaw rate.

b) Provide clearly labeled plots of the simulated vs. experimental 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).

2) Simulate the E-class performing a step steer input that provides a final yaw rate of 50 deg/s. You can use “lsim” or “step” 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) Simulate the E-class doing a lane change maneuver. Use the sine function below for the steer angle input.

$$\delta(t) = 0.2 \times \sin(2\pi \times (t - 0.5)) \qquad 0.5 \le t \le 1.5$$
$$\delta(t) = 0 \qquad 0 \le t \le 0.5 \text{ and } 1.5 \le t \le 3$$

a) Simulate the maneuver at 15 m/s 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. What happens? Why?

c) Scale the magnitude of the steer angle input until you get a 4 m-lane change at 30 m/s. This will have to be done through trial and error. Plot the steer angle, yaw rate and sideslip angle on one page and the heading angle and lateral position on another page. What was the magnitude of the steer angle?