

## CarSim Problems

### Rollover

The NHTSA has established a procedure for measuring rollover propensity of highway motor vehicles. They are now testing new SUVs for this property and rating them with a five-star system in the NCAP (New Car Assessment Program).

#### Part A

In this homework you are to use CarSim to replicate a portion of this procedure on the Big SUV. Follow the instructions for Exercise #6 – Part A to replicate the following:

#### NHTSA Test Procedure

- 1) Set the speed to 80.5 km/h (50 mph) and increase the steering wheel angle from 0 – 270 degrees at a rate of 13.5 degrees per second. Determine the steering wheel angle at which the lateral acceleration is 0.3 g. Multiply this angle by 6.5 to obtain the steer angle for the tests (TSA).
- 2) With the vehicle at a speed of 56.3 km/h (35 mph), ramp the steering wheel left to TSA at a rate of 720 deg/sec. When the roll rate drops below 1.5 deg/sec, immediately ramp the steering wheel angle to –TSA at 720 deg/sec. Observe to see if both wheels lift off on one side of the vehicle. If so, the vehicle fails the test.
- 3) Repeat this test at progressively higher speeds of 64.4 (40), 72.4 (45), 76.4 (47.5) and 80.5 km/h (50 mph) looking for lift off of both wheels on one side of the vehicle during a run to determine if the vehicle fails the test.
- 4) *NHTSA procedure calls for repeating this procedure (steps 1 – 3) steering in the opposite directions. If the vehicle passes all these tests NHTSA would repeat the tests using a TSA that is 5.5 times the steer angle obtained at 0.3 g in Step 1. However, these are not required for this assignment.*

#### Part B

1) The SUV will roll over if the CG is high enough. Find its rollover limit by increasing the sprung mass CG height incrementally until you get both wheels to lift. Print the Plot screen for this case.

2) Compare your results to what would be calculated by using Eqn. 9-6 from the textbook. For that calculation you need the track width of the SUV, the CG height (which you can calculate from the SUV data), the roll center height of the suspensions (take the average of the front and rear), and the roll rate (radians of roll per g lateral acceleration). You can find the roll rate by performing the ramp steer test again on the SUV with the elevated CG and plotting Roll vs. Ay.

3) Compare your calculated lateral acceleration for the rollover limit to the value at wheel lift off in the simulation.

**CarSim Exercise**  
**NHTSA Rollover Test**

- 1) Select the *Data Set*: Rollover: NHTSA Fishhook: Stable. Click New, put your name in the category, and give it the Title: Baseline SUV. Make the following changes on the Runs Control screen;
  - a. Click *More* in the middle column and change the Output file Time step to 0.01 sec. (*This will provide better resolution in the plots.*)
  - b. Unclick the *Overlay Other Runs* box in the right column.
  - c. Change the Plot selection to Steer SW-steering wheel; Roll Rate (body-fixed), vehicle; Ay – lat. accel of CGs; and Fx – vertical forces (Car) (All)
- 2) Click New again and give the run the Title: Baseline SUV - Ramp Steer.
- 3) Go to the Steering Control screen, click New and label it NHTSA Ramp Steer. Enter the values 0, 0; 20, 270. (This is the ramp steer specified in the NHTSA test procedures).
- 4) Choose this steer input on the Runs Control screen and run the simulation. On the plot screen, find the time at which the lateral acceleration reaches 0.3 g. Then on the steering wheel angle plot find the steering wheel angle corresponding to the time. Multiply this value by 6.5 to obtain the Test Steer Angle (TSA).
- 5) Now select your original Baseline SUV run again. Go to the Steering control screen, click New and give it the title; Baseline Fishhook. Enter values as follows
  - a. 0, 0
  - b. T1, TSA where  $T1 = TSA/720$  (This sets the NHTSA steering rate)
  - c. 10, TSA
- 6) Make a run with this steering input. On the Roll Rate plot find the time when the roll rate drops below 1.5 deg/sec at the end of the initial spike. Note this time, T2.
- 7) Return to your Steering control screen and change it as follows:
  - a. 0, 0
  - b. T1, TSA
  - c. T2, TSA
  - d. T3, -TSA where  $T3 = T2 + TSA/360$
  - e. 10, -TSA

- 8) Run the simulation again at each of the test speeds (56.3, 64.4, 72.4, 76.4 and 80.5 km/h). Note how the behavior changes with increasing speed. Print the Plot screen from this highest speed.

**CarSim Exercise**  
**Rollover Threshold**

- 1) Keep the initial speed at 80 km/h.
- 2) Go to the Vehicle: Sprung Mass screen where the CG height is specified. Increase the CG incrementally until you achieve simultaneous lift off of both wheels on one side of the vehicle. Print the Plot Screen for this case.
- 3) Run the Ramp Steer test to determine the Roll Rate for this condition.