CarSim Problems
Dynamic Loads

1) The CarSim " Big SUV" example vehicle has the following properties:

Sprung Mass:	Mass = 2210 kg	CGx = 1070 mm	CGz = 660 mm
Front Unsprung:	Mass = 120 hg	CGx = 0 mm	CGz = 379 mm
Rear Unsprung:	Mass = 120 kg	CGx = 2850 mm	CGz = 379 mm
Wheelbase:	2850 mm		

a) Find the longitudinal and vertical locations of the composite CG (sprung + unsprung masses).

b) Determine the static axle loads based on the CGx location.

c) Determine the dynamic axle loads when it is accelerating on a level road at 0.2 g.

d) Determine the dynamic axle loads when it is on a 6% (3.4-degree slope)

e) Compare the static and dynamic loads of the two axles you calculated to the values you would get using CarSim (Exercise #1, Part A) and determine the percent difference between the calculated and simulated. Use the tabular format like that shown below:

	Calculated	Simulated	Error
Front Static	_____	_____	_____
Rear Static	_____	_____	_____
Front Dynamic (0.2 g)	_____	_____	_____
Rear Dynamic (0.2 g)	_____	_____	_____
Front Dynamic (6%)	_____	_____	_____
Rear Dynamic (6%)	_____	_____	_____

2) A 1-axle trailer has the following properties;

Wheelbase (hitch to axle) 2600mm

Sprung Mass:	Mass = 466 kg	CGx = 2000 mm	CGz = 971 mm
Payload	Mass = 500 kg	CGx = 2500 mm	CGz = 1000 mm
Unsprung Mass:	Mass = 136 kg	CGx = 2600 mm	CGz = 305 mm
Hitch height:	560 mm		

a) Find the static hitch and axle loads of the trailer.

b) Find the static axle loads of the SUV above when the trailer is connected to its hitch. The SUV hitch is 1150 mm behind the rear axle.

c) Find the trailer hitch load and towing force when the trailer is being accelerated on a level road at 0.2 g. (The hitch height on the SUV is 560 mm above the ground)

d) Find the axle loads of the SUV above (Problem 1) when it is towing the trailer and experiencing an acceleration of 0.2 g on a level road.

e) Compare the static axle loads of Part b and the dynamic axle loads of Part d to what is obtained via the CarSim simulation of the car-trailer combination (CarSim #1b). Show the results in the tabular form of the following table:

	Calculated	Simulated	Error
SUV Front Static	_____	_____	_____
SUV Rear Static	_____	_____	_____
Hitch Load static	_____	_____	_____
Hitch Fx static	_____	_____	_____
Trailer Static Axle	_____	_____	_____
SUV Front (0.2 g)	_____	_____	_____
SUV Rear (0.2 g)	_____	_____	_____
Hitch Load (0.2 g)	_____	_____	_____
Hitch Fx (0.2 g)	_____	_____	_____
Trailer Axle (0.2 g)	_____	_____	_____

CarSim Exercise #1

CarSim #1a — Axle loads on an SUV: Static and climbing a hill

Objective: To examine the static and dynamic axle loads on a vehicle.

1) Start CarSim and on the Run Control screen select the data set *Trailer Towing: SUV, Big: with 1A-Trl @DLC, 50 km/h*. Click New and in the Title give it the name Big SUV HW1b&c. Type your name into the Category field.

2) Click on the Blue Link under the Vehicle to go to the Vehicle Assembly screen. When there click New, label it as *SUV, Big w/o Trailer*. Put your name in the Category field. Now uncheck the Trailer box under the picture. Go back to the Run Control screen and select the vehicle you just built.

3) Now set it up to duplicate Parts b and c of the problem by doing the following:

   a. Under Controls: Steering Driver Path Follower, change the blue link to *Constant position No offset @ 0.5 sec preview*.

   b. Under the Environment: Road/wind/misc., change the blue link to *Straight: Flat*.

   c. In the Plot menu, select the following plotting choices (turn other plots off):

      i. Tire Forces: *Fz – vertical forces (Car) (All)*

      ii. Vehicle Motion: *Ax – long. accel of CGs*

4) Now let's give it a constant acceleration so we can duplicate Parts a and b of the problem. In the gray box in the left column that says "Constant target speed," set it to "Target speed vs. time." Click on the blue field below it to get to a Control: Speed vs Time screen. Click new and label the data set as "Ramp @ 0.2 g." The control is a PI (proportional-integral). It will work best for this application if you change the Proportional gain to 1, and the Integral gain to 0. Now in the Time-Speed table enter the numerical values below:

0.0, 0.0	
4.0, 0.0	The first four seconds allows you to look at static loads
14.0, 70.6	This accelerates at 0.2 g for ten seconds

Click Refresh in the lower right corner to make sure you got the table you wanted.

5) Go back to the Run Control screen, select this new Ramp speed and set the simulation to stop at 14 seconds.

6) Run the simulation, check the animation to make sure it looks right, then choose the plots to see the results.

7) Now let's look at some of the relevant calculations.

a. First check that the vehicle accelerated at 0.2 g. Notice that the accelerations are not perfectly smooth. Why? Well real vehicles experience transients when they begin to accelerate, and then periodically shift.

b. Look at the wheel loads plot. Note that the axle load is the sum of the loads from two wheels. Second, observe that once the vehicle is accelerating, the wheel loads differ slightly from side to side. (When we look at powertrains we will see that this is due to driveline torque.) Sum the wheels loads on each axle to get the "dynamic axle load" needed in the problem. (Note: to read values from the plot, hit Ctfl+D and use the arrow keys to read values.)

8) Print a copy of the plot screen to include with your homework. (I.e., Hit the Print Screen key when on the WinEP plots page.)

9) To simulate the SUV on a slope, select New on the Run Control screen and name it Big SUV HW1d. Change the speed control to Constant target speed and set it to 10 km/h. Now go to the road screen and make up a new one with a 6% grade (e.g. data points 0,0: 50, 3: 100,6 (You need three road data points because it uses a spline fit).

10) Run the simulation and determine the wheel loads after the initial transient settle out.

11) Print a copy of the plot screen in include with your homework.

CarSim #1b — Axle loads on a SUV-trailer combination

Objective: To examine the static and dynamic axle loads on a SUV-trailer combination.

1) Go back to the Run Control screen from CarSim #1a. Click New and label DataSet as Big SUV HW1Part2. Under the vehicle choose SUV, Big w/ 1A-Trailer.

2) Check that the speed control is set to Ramp @ 0.2 g, and the road is Flat. Add a new plot for the trailer hitch forces by choosing Hitch: *F hitch – hitch forces*. Also change the wheel forces plot to *Fz – vertical forces (Trailer) (All)*. In order to have the trailer forces included in the output of the run, check the More box in the center of the Run Control screen, and then change Basic Outputs to All Outputs.

3) We also need to make a couple of changes to the trailer.

a. On the Vehicle: Trailer with 1-Axle, click on the Front Compliance link. Click New to get the name Trailer Axle #1. Now change the link under each of the springs to 15N/mm, Bmp 2700, Strk 160 mm, and under both Shock Absorbers select the link Small Car Damping. Set all of the Compliance Coefficients in the lower left of the screen to zero.

b. Go back to the trailer screen, select New, give it a name and set the suspension link to the one you just created. Under Hitch info, click on the

example hitch link. Then on the Hitch: Joint Assembly page, click New and set all the hitch moments to have zero moment (Zero Roll Stiffness, 90-90 Deg Lash for the Pitch Stiffness, and 260 Deg Lash for the Yaw Stiffness)

c. Go to the trailer Sprung Mass screen. Click New, give it a name and change the hitch height to 560 mm, and the wheel center height to 305 mm.

d. Be sure to connect this trailer to your SUV.

4) Run the simulation and determine the forces required for Part 2 of the homework. Print a copy of the plot screen to include with your homework.