

### CarSim Problems Powertrain

The CarSim “Sedan, Large, RWD” has the following properties.

Total mass (sprung and unsprung): Mass = 1707 kg  
Torque converter ratio at stall: 1.864          K-factor: 312.5

Engine properties:

Inertia: 0.16 kg-m<sup>2</sup>  
RPM            600        1000        2000        3000        4000        4500        5000        6000  
Torque (N-m) 163        179        203        213        220        226        222        188

Transmission:	Ratio	Efficiency	Inertia (kg-m <sup>2</sup> )
1 <sup>st</sup> gear	3.80	0.9	0.37
2 <sup>nd</sup>	1.96	0.9	0.34
3 <sup>rd</sup>	1.40	0.9	0.42
4 <sup>th</sup>	1.0	0.9	0.4
5 <sup>th</sup>	0.7	0.9	0.4
Final drive:	4.4	1	0.1*

Wheel radius: 301 mm          Inertia: 4.4 kg-m<sup>2</sup> (total for 4 wheels)\*

(\*Note: CarSim shows a zero value for the inertia of the final drive and wheels, however we will use the values listed above. It is not necessary to change the CarSim values for simulations in this homework.)

- 1) Calculate the Mass Factor for this vehicle in each of the five gears.
- 2) As a powertrain engineer for your company, you are responsible for making sure driveline components have adequate strength. One of the tests you use is to hold the vehicle stationary with the brakes while you apply full throttle in first gear.
  - a) What is the stall RPM of the engine? (Remember:  $K = RPM / \sqrt{T}$ )
  - b) Calculate the torques present in the driveline at the following locations:
    - Engine crankshaft output
    - Torque converter output (Transmission input)
    - Transmission output
    - Final drive output (total torque on both axles)
  - c) Perform this experiment with CarSim (Exercise 2a) and see how the simulated torque values compare with the calculated for the following (Final drive is not shown in CarSim).

	<u>Calculated</u>	<u>Simulated</u>	<u>Error</u>
Engine stall speed	_____	_____	_____
Engine output torque	_____	_____	_____
Torque converter output	_____	_____	_____
Transmission output torque	_____	_____	_____

3) The car is driving on a level road in 3rd gear at a speed of 80 km/h.

- a) Calculate the speeds in the driveline at the same locations as in Problem 2. I.e.,  
 Torque converter output (RPM)  
 Transmission output (RPM)  
 Final drive output (wheel speeds in RPM)

b) Perform this experiment with CarSim (Exercise 2b) and see how the simulated speed values compare with the calculated for the following (Wheel speeds in RPM are not shown in CarSim).

	<u>Calculated</u>	<u>Simulated</u>	<u>Error</u>
Transmission input	_____	_____	_____
Transmission output	_____	_____	_____

4) One can make rough estimates of vehicle acceleration performance based on the power to weight ratio.

a) Derive and solve the differential equation relating velocity to distance, assuming constant power is delivered to the wheels.

Assuming the effective mass averages 20% greater than its weight in the gears being used (i.e., 2048 kg, instead of 1707) and about 70% of the engine power of 118 kw is delivered to the ground, what speed would be predicted for this vehicle in 1/4 mile (402 m) standing start?

b) Derive and solve the differential equation relating time and distance, assuming constant power is delivered to the wheels.

Using the same assumptions as in Part a above, what would be the “quarter-mile” time?

c) Run a simulation with CarSim (Exercise 2c) and see how closely the results compare.

	<u>Calculated</u>	<u>Simulated</u>	<u>Error</u>
Quarter-mile speed	_____	_____	_____
Quarter-mile time	_____	_____	_____

## CarSim Exercise #2

### CarSim #2a – Stall torque loads

Objective: To determine loads in driveline components at stall.

- 1) Start CarSim and on the Run Control screen select the data set *Powertrain: Sedan, Big: RWD: Full Throttle*. Click New and give it the name HW2: Stall Test. Type your name into the Category data field. Go to the Sprung Mass page and set the wheel height to 301 mm (4 wheels).
- 2) First, let's set the brakes. On the left side click on Braking. On the Control: Braking screen, make up a New data set. Label it Constant @ 100 MPa (This is a really high value, but don't worry – You can't break the brakes in a simulation). Now make up a table with immediate brake application (I.e., 0,100: 10,100). Go back to the Run screen and select this braking table.
- 3) Set the Throttle Control to Ramp to Full Throttle.
- 4) In the middle column set the simulation Stop Time to 5 seconds. Click More and set the simulation Time Step to 0.0001 seconds (this will reduce instabilities in the calculations).
- 5) Set up the Plotter to show Vx – wheel speeds (all); Torques in powertrain; Spin rates in powertrain; and Gear from Automatic Transmission.
- 6) Run the simulation and look at the Engine Speed and the Torques in the Powertrain and read off the values of interest.
- 7) 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.)

### CarSim #2b – Driveline speeds

Objective: To determine speeds in the driveline at 80 km/h.

- 1) Go back to your run and turn off the braking. Choose Constant Target Speed and enter the value of 80. Under Throttle, choose No Data Set. Under Shifting control choose AT 3<sup>rd</sup> mode (This locks it in third gear).
- 2) Increase the simulation time to about 10 seconds, run the simulation and go to the plots.
- 3) Go to the plot of Spin Rates in Powertrain and read off the speeds for the transmission input and output shafts once the vehicle settles to a steady speed.
- 4) 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.)

### CarSim #2c – Quarter-mile Acceleration

Objective: To determine the speed and time in a quarter-mile acceleration.

- 1) Go back to the Run Control screen and select New, naming this run the Quarter Mile. In the speed control link, change it from Constant Target Speed to Initial Speed (open-loop control) and change the speed to 0 km/h. Go to the Throttle from Driver link and select Ramp to Full Throttle. Set the simulation time to 20 seconds
- 2) Go to the Vehicle: Assembly screen and choose No Aerodynamics (since we are not taking this into account). Then on to the Powertrain link to the 2.5l, Viscous Gear 4.4 screen. On the Powertrain: Rear-Wheel Drive screen click on the Transmission link. This shows you the transmission parameters.

It turns out the Upshift table for this transmission are not very optimal, so we will change it. Click on the Upshift Schedule link. Once there, select New and name it Corrected Upshift Schedule. Change the table entries as follows:

First to second gear	0.86, 1600	to	0.86, 1400
	1.0, 1600	to	1.0, 1400
Second to third gear	0.86, 3000	to	0.86, 2600
	1.0, 3000	to	1.0, 2600
Third to fourth gear	0.86, 4600	to	0.86, 3900
	1.0, 4600	to	1.0, 3900
Fourth to fifth gear	0.86, 5700	to	0.86, 5200
	0.87, 6000	to	0.87, 5200
	1.0, 6000	to	1.0, 5200

(Fifth to sixth and sixth to seventh don't matter because they are not used.)

- 3) Go back to the Transmission screen, click New and rename it Corrected Transmission, then select your new Upshift schedule. Go back to the Powertrain: Rear-Wheel Drive screen, click New, rename it 2.5L, Viscous, HW 2 and select the transmission you just made. Go back to the Vehicle: Assembly screen, click New, rename it to Sedan, Big Quarter Mile Test, and select the powertrain you just made.
- 4) Go to the Run screen, click New, rename it Quarter Mile, and run the simulation.
- 5) Add another plot to the plotter -- Tracking : S vs T – station vs time. Make the plots and find the quarter-mile time (when the car reaches 402 m). From the Speed v. Time plot, find the speed of the vehicle CG at that time. Compare these two values to what you calculated in Part 4c.
- 6) 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.)