MathWorks | Training Services

Exercises: Vehicle Modeling

Student Competition - Physical Modeling Training

Car Body and Tires

In this exercise, you will create a simple car model using SimDriveline™ blocks.

Use blocks from the **SimDriveline → Tires & Vehicle**s library to create a car model with the parameters shown to the right.

Simulate the model under the following wind and terrain conditions.

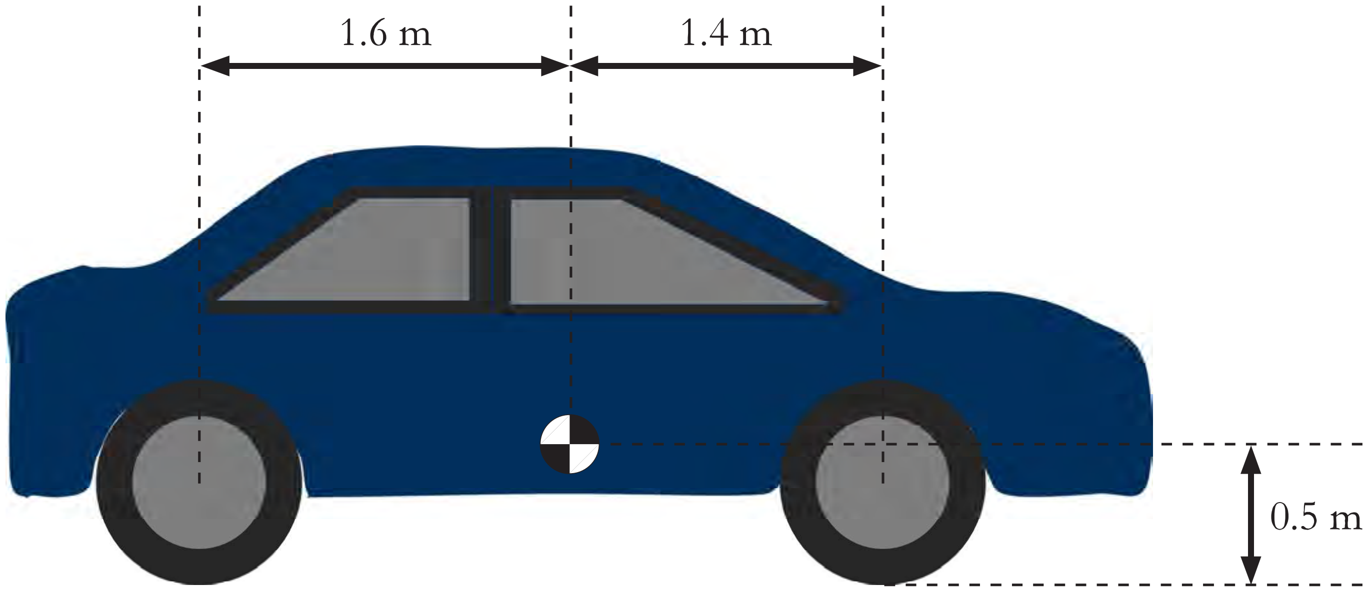
- Road inclination: 2° downward
- Headwind speed: 3 m/s

Measure the speed of the car in km/hr and connect it to a Simulink scope.

Parameters

Vehicle body:
Vehicle mass: 1500 kg
Wheels per axle: 2
Frontal area: 3 m^2
Drag coefficient: 0.4
Distances are shown on the diagram below.

Tires (magic formula):
Rolling radius: 16 in (406.4 mm)
Tire stiffness: 200000 N/m
Tire damping: 1000 N/(m/s)
Tire inertia: 4.129 kg/m^2
Rolling resistance: 0.015



Solution: Car Body and Tires

1. Create a new model configured for physical networks.

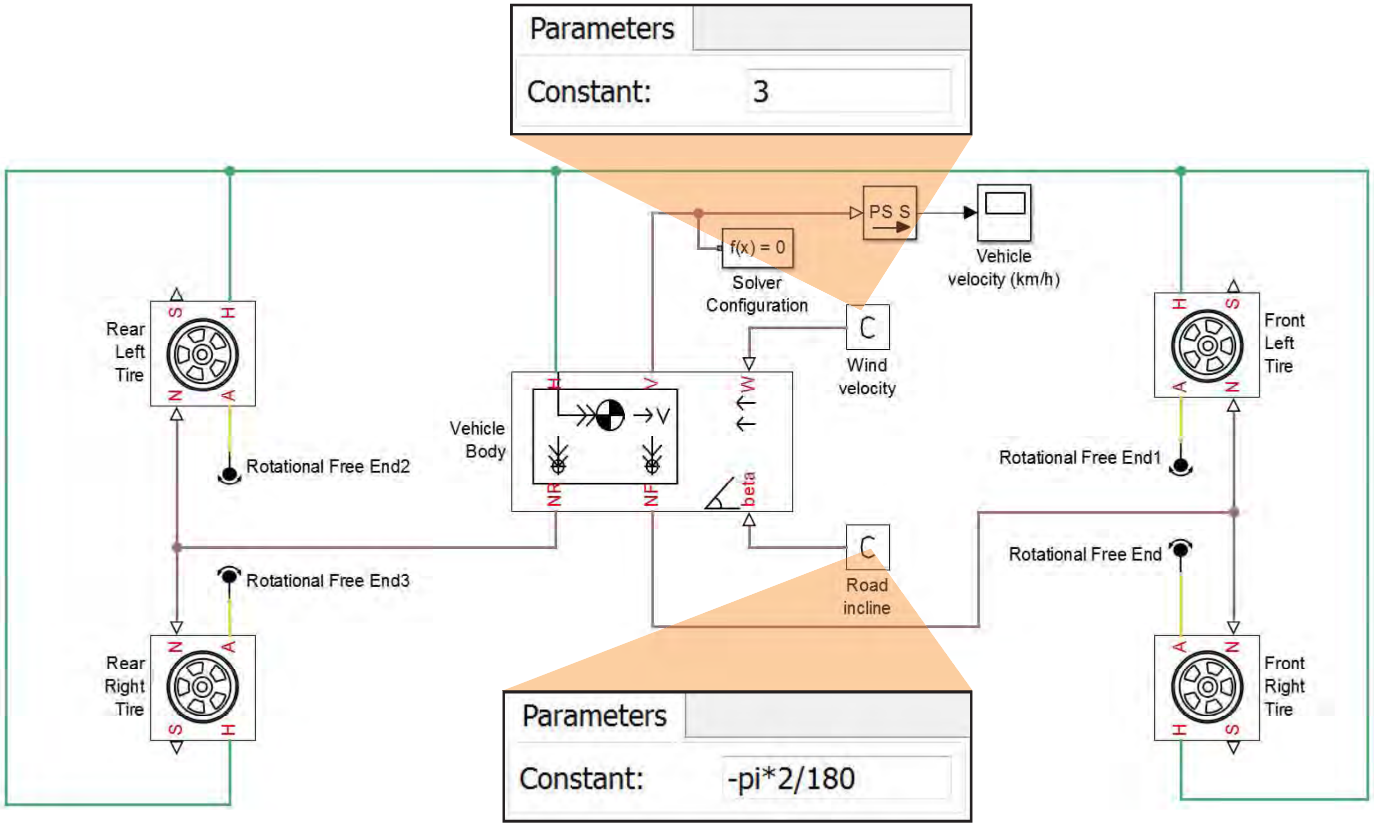
   ```
   >> ssc_new
   ```

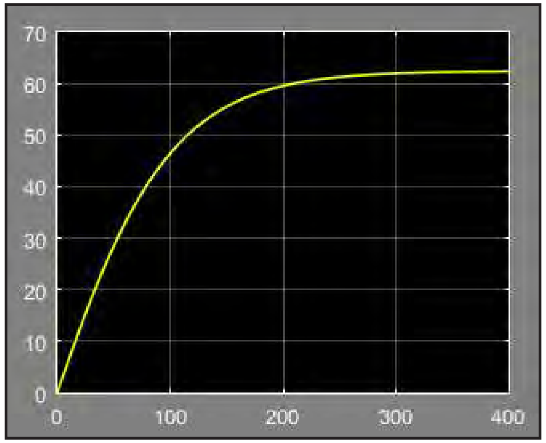
2. Add a Vehicle Body block and four Tire (Magic Formula) blocks from the **SimDriveline → Tires & Vehicles** library, and connect them as shown below. Set the block parameters as shown on the previous page. All unlisted parameters should remain at their default values.
3. Connect Rotational Free End blocks (**Simscape → Foundation Library → Mechanical → Rotational Elements**) to the axle (A) ports of the Tire blocks.

Try

```
>> carDynamicsSoln
```

4. Add two PS Constant blocks (**Simscape → Foundation Library → Physical Signals → Sources**) and connect them to the wind (W) and road inclination (beta) ports of the Vehicle Body block.
5. Measure the vehicle speed using the V port of the Vehicle Body block. Set the Output signal unit of the PS-Simulink Converter block to `km/hr`.
6. Simulate the model for 400 seconds and find the final car velocity (approximately 62 km/hr).





Car Brakes

In this exercise, you will add brakes to the front wheels of a car model and analyze the measurements.

The `carBrakeStart` model represents a car with four tires. The rear wheels are powered with a Generic Engine block and a simple transmission system (torque converter, gear, and differential).

The model has several subsystems that contain various sensor blocks. The outputs of these sensors are connected to the Scope blocks to the right of the block diagram. You can use these scopes to view useful tire quantities.

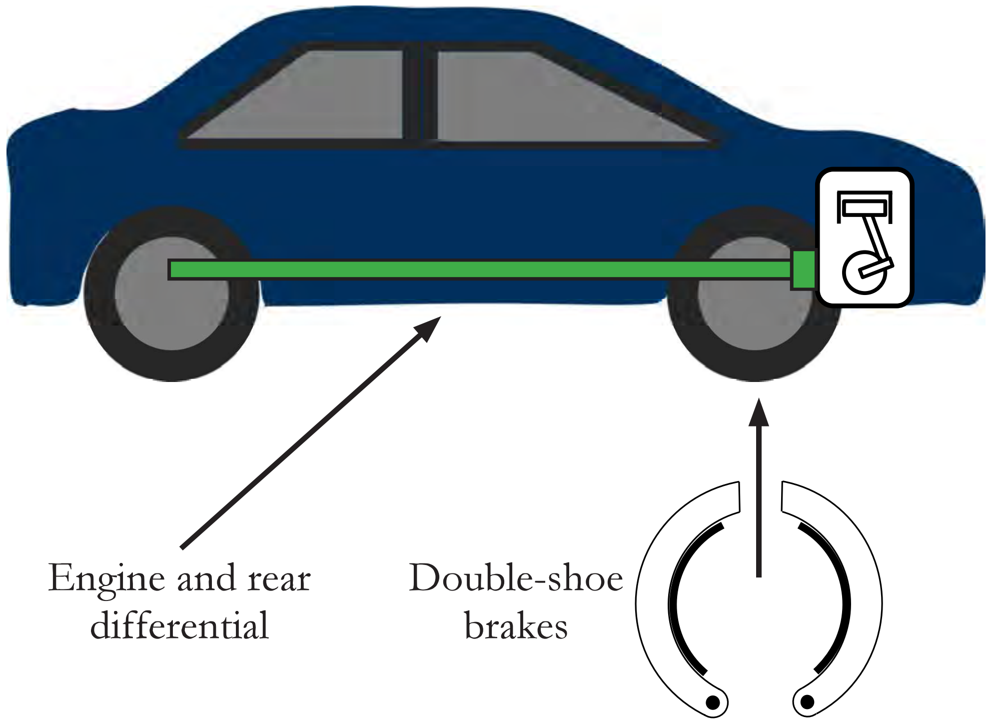
1. Add double-shoe brakes to the front wheels of the car model, using the parameters shown on the right. Connect the brake force signals provided to the brakes.
2. Simulate the model and view the measurements.
3. Create an asymmetric braking strategy by changing the step time of the right brake force from 30 seconds to 35 seconds. Compare the measurements with the symmetric braking case.

Parameters

Drum radius: 200 mm
Actuator location radius: 150 mm
Pin location radius: 125 mm
Pin location angle: 15°
Shoe beginning angle: 5°
Shoe span angle: 120°
Viscous friction coefficient: 0.01 N*m/(rad/s)
Contact friction coefficient: 0.3

Try

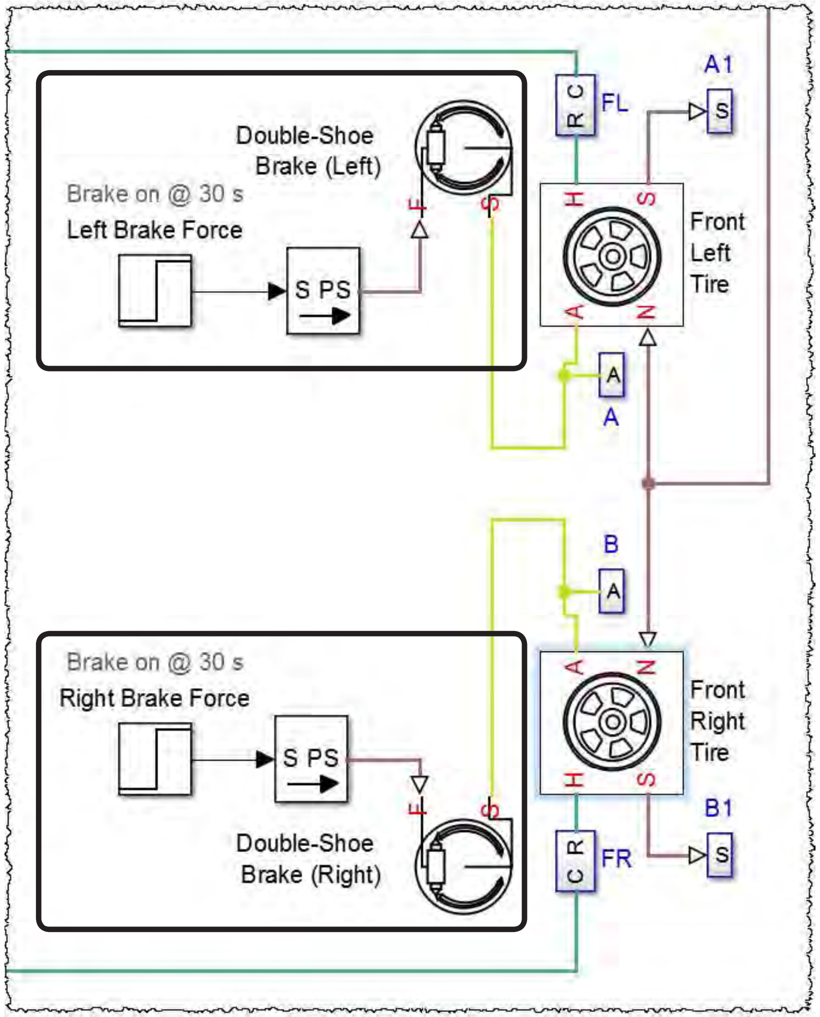
```
>> carBrakeStart
```



Solution: Car Brakes

1. Add two Double-Shoe Brake blocks from the **SimDriveline → Brakes & Detents → Rotational** library. Set the block parameters as shown on the previous page.

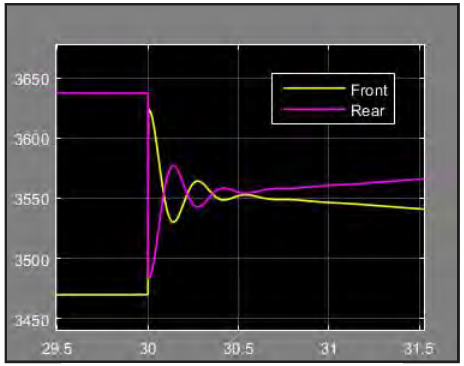
   Use Simulink-PS Converter blocks to connect the Simulink step signals to the Double-Shoe Brake blocks.



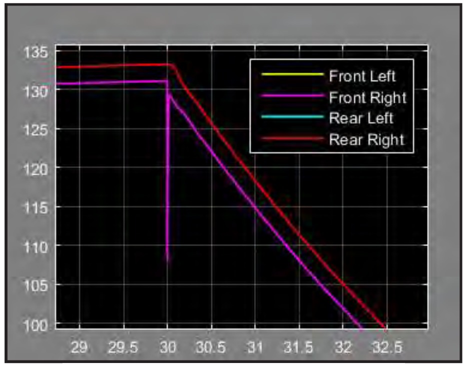
Try

```
>> carBrakeSoln
```

2. Measure tire quantities with both brakes applied at 30 seconds. With both brakes applied simultaneously, weight is transferred to the front wheels between 30 and 30.5 seconds. Both front wheels rotate at the same speed, which is lower than the rear wheel speed.

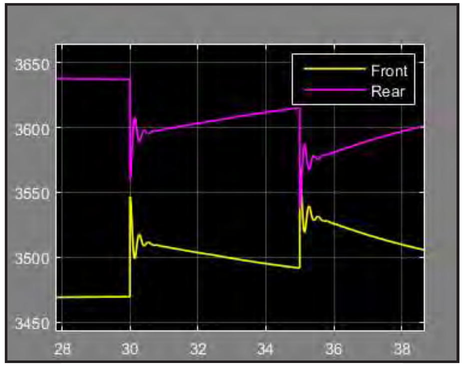


Normal tire forces (N)

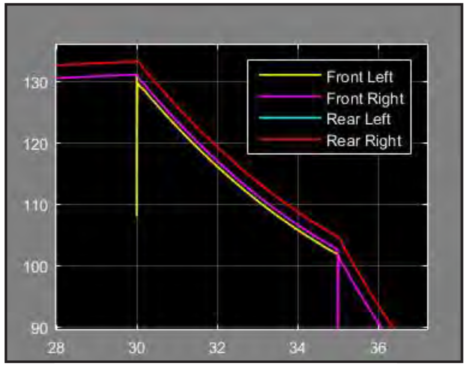


Wheel speeds (RPM)

3. Measure tire quantities with the asymmetric braking strategy. The longitudinal braking force is divided into two steps, so the majority of the weight is almost always on the rear wheels. The front wheels spin at different speeds between 30 and 35 seconds.



Normal tire forces (N)



Wheel speeds (RPM)