Exercises: Powertrain Modeling

Student Competition - Physical Modeling Training

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Four-Wheel Drive Car

In this exercise, you will convert a rear-wheel drive car model to a four-wheel drive model.

The model `carTransStart` represents a rear-wheel drive car with a flexible driveshaft.

1. Create a chain drive transfer case to transmit power from the engine to the front wheels of the car. Use the parameters shown on the right.
2. Note that the front and right wheel brakes are applied at different times. Connect a differential to the front wheels to allow the wheels to rotate at different speeds. The differential axle ratio is the same as the rear differential.
3. Use the transmission ratios of the chain and front driveshaft to determine the gear ratio needed such that the front and rear wheels spin at the same speed. This is necessary to avoid excessive wheel slip.
4. Add a front driveshaft inertia of 0.01 kg*m^2 between the transfer case and differential.

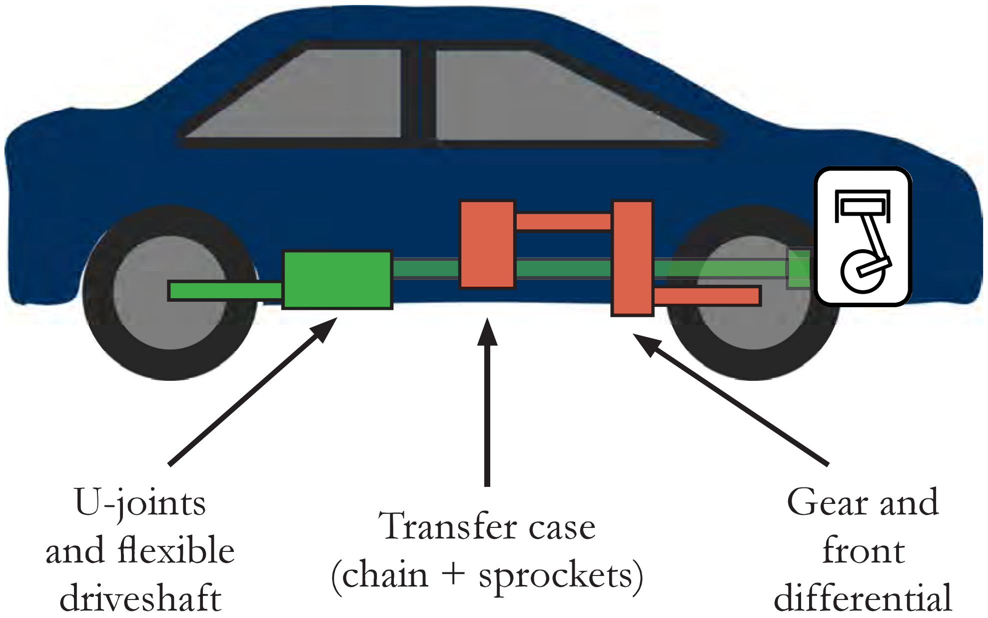
Parameters

Chain drive:
Engine sprocket radius: 80 mm
Front driveshaft sprocket radius: 40 mm
Chain slack length: 50 mm
Chain stiffness: 100000 N/m
Chain damping: 5 N/(m/s)
Viscous friction: 0.001 N*m/(rad/s)

Gear and front differential:
Front differential axle ratio: 4
Front driveshaft inertia: 0.01 kg*m^2
No meshing friction losses

Try

```
>> carTransStart
```



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Solution: Four-Wheel Drive Car

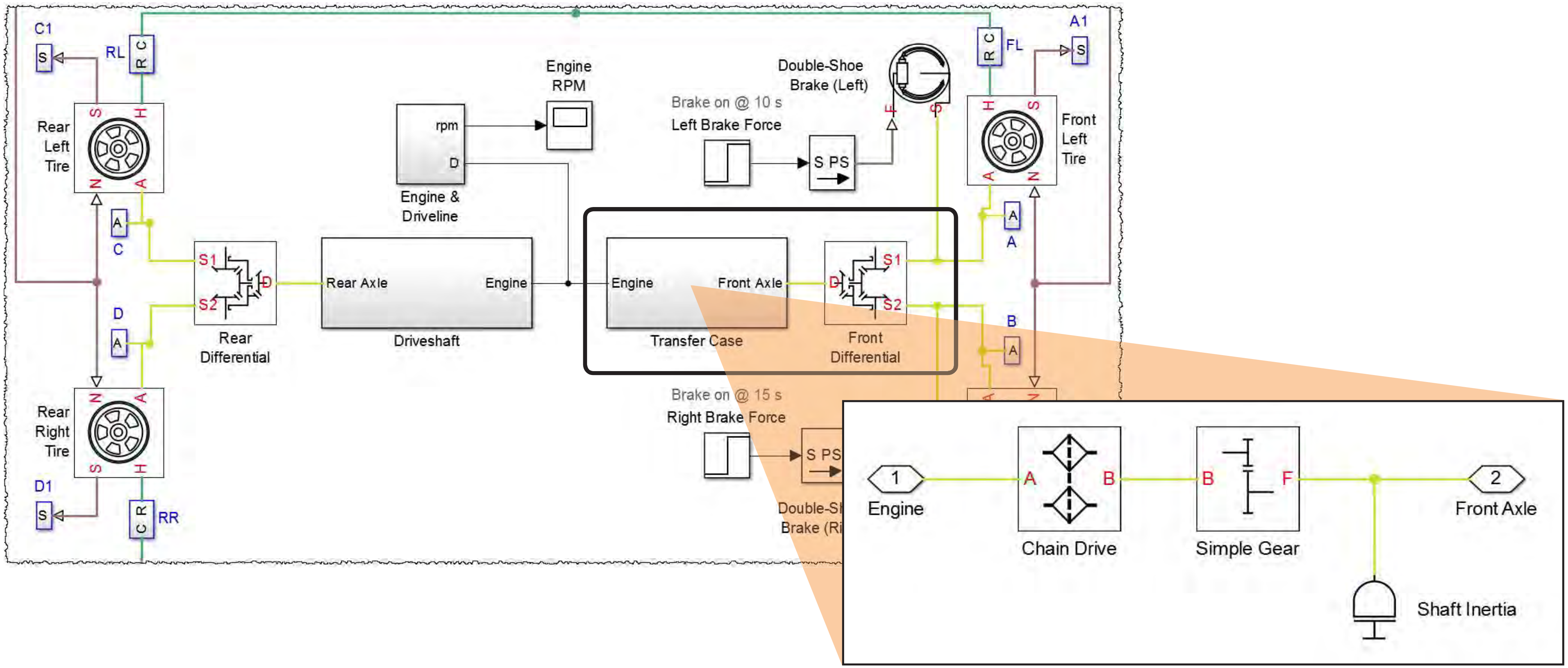
1. Add a Chain Drive block from the **SimDriveline → Couplings & Drives** library. Set the parameters as shown on the previous page.
2. Connect the S1 and S2 ports of a Differential block (**SimDriveline → Gears** library) to the front wheels.
3. Add a Simple Gear block (**SimDriveline → Gears** library) between the Chain Drive and Differential blocks. Because the chain sprocket radii are 80 and 40 mm, the front driveshaft will spin twice as fast as the rear driveshaft. Set the **Follower to Base teeth ratio** to `2`. Also, set the **Output shaft rotates** parameter to `In same direction as input shaft`.

Try

```
>> carTransSoln
```

4. Add an Inertia block (**Simscape → Foundation Library → Mechanical → Rotational Elements** library) between the Simple Gear and Differential blocks. Set its **Inertia** to `0.01` kg/m^2.

View the measurements and verify that power is being delivered to both the front and rear wheels of the car model.



Pneumatic Clutch Actuator

In this exercise, you will model a simplified pneumatic clutch actuator. This actuator consists of a variable air pressure source entering a spring-loaded pneumatic cylinder.

When the pressure increases, the cylinder pushes both ends of the clutch together. When the pressure decreases, the spring moves the cylinder back to its rest position.

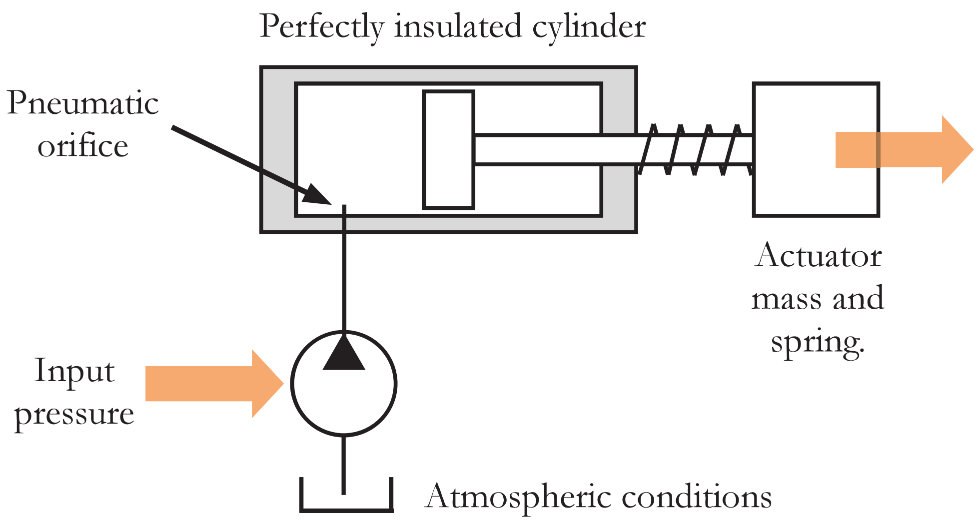
1. Open the `pneumaticClutchStart` model and navigate inside the Pneumatic Clutch Actuator subsystem.
2. Add blocks from the **Simscape → Foundation Library → Pneumatic** and **Simscape → Foundation Library → Mechanical** libraries to model the actuator based on the schematic and parameters on the right.
   - **Hint 1** Convert the pressure signal provided into a pneumatic pressure physical signal, which you can then connect to the appropriate Simscape source block. Use kilopascals (`kPa`) as the conversion unit.
   - **Hint 2** The Pneumatic Piston Chamber block can convert between the pneumatic and mechanical translational domains. The H port of this block is a thermal port. For simplicity, you can assume there is no heat transfer and connect this port to an Adiabatic Cup block from the Pneumatic Elements library.
3. Simulate the model and view the results.

Parameters

Pneumatic orifice area: 5e-5 m^2
Pneumatic piston area: 2.5e-3 m^2
Actuator mass: 100 g
Actuator spring stiffness: 250 N/m
Initial piston extension: 0 m

Try

```
>> pneumaticClutchStart
```



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Solution: Pneumatic Clutch Actuator

First, add a Simulink-PS Converter block and convert the input pressure to kilopascals (`kPa`). Connect this physical signal to a Controlled Pneumatic Pressure Source from the Pneumatic Sources library.

The other blocks you will need are

Pneumatic Elements:

- Adiabatic Cup
- Constant Area Pneumatic Orifice
- Pneumatic Piston Chamber

Translational Elements:

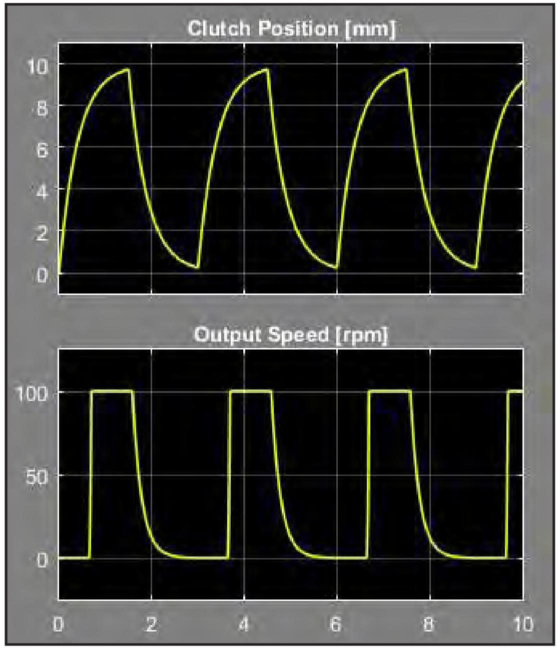
- Mass
- Mechanical Translational Reference
- Translational Spring

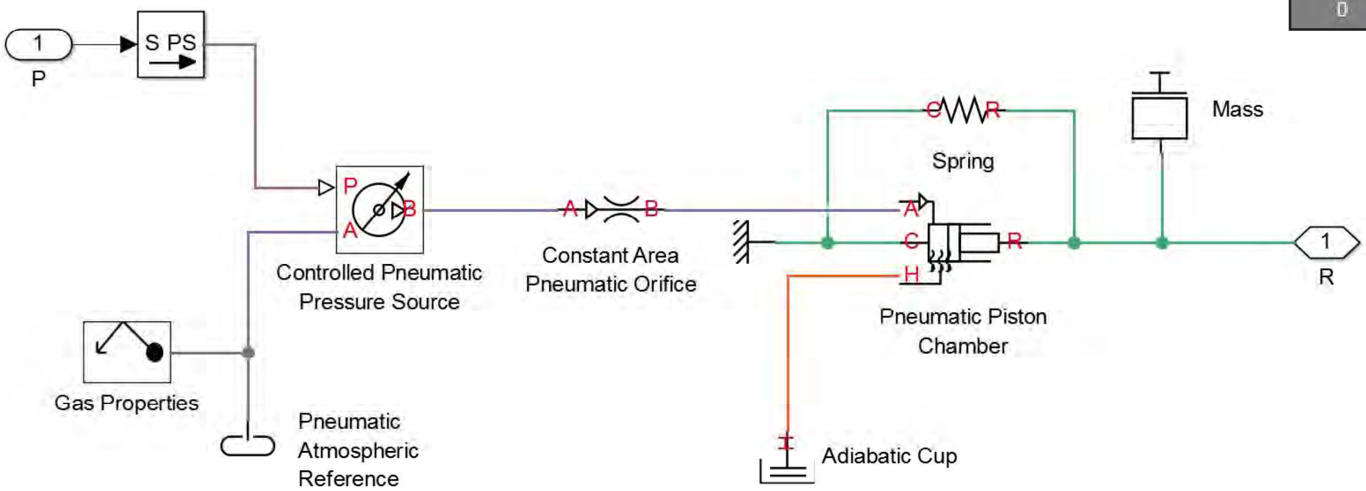
Try

```
>> pneumaticClutchSoln
```

The simulation results are shown on the right.

The clutch engages when the actuator position is above 5 mm. When the clutch disengages, the damping on the shaft causes it to slow down until it comes to rest.





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