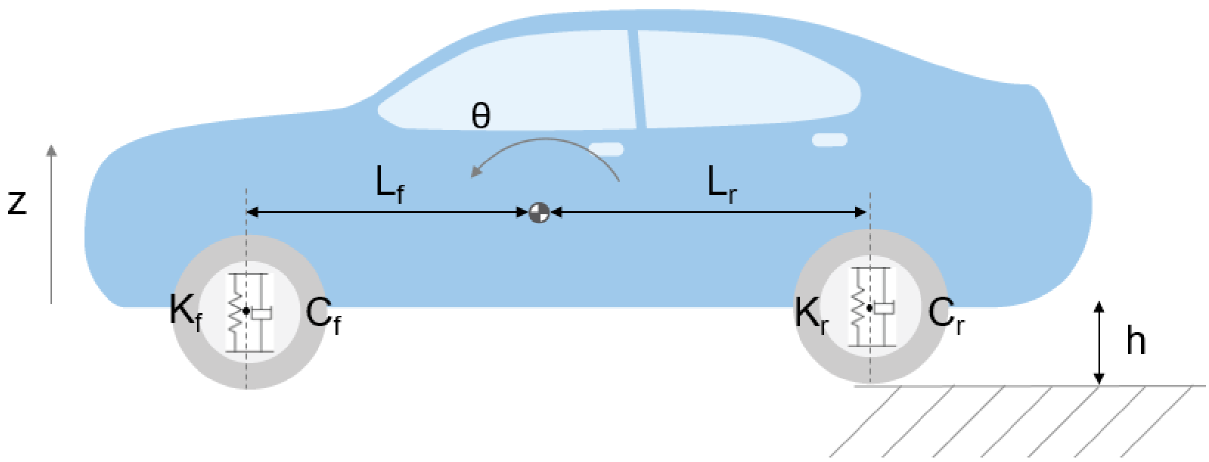
VEHICLE SUSPENSION SYSTEM MODEL

This system shows how to model a simplified half-car model that includes an independent front and rear vertical suspension. The model also includes body pitch and bounce degrees of freedom. The example provides a description of the model to show how simulation can be used to investigate ride characteristics. You can use this model in conjunction with a powertrain simulation to investigate longitudinal shuffle resulting from changes in throttle setting.



Free-body diagram of the half-car model

The illustration shows the modeled characteristics of the half-car. The front and rear suspension are modeled as spring/damper systems. A more detailed model would include a tire model, and damper nonlinearities such as velocity-dependent damping (with greater damping during rebound than compression). The vehicle body has pitch and bounce degrees of freedom. They are represented in the model by four states: vertical displacement, vertical velocity, pitch angular displacement, and pitch angular velocity. A full model with six degrees of freedom can be implemented using vector algebra blocks to perform axis transformations and force/displacement/velocity calculations. **Equation 1** describes the influence of the front suspension on the bounce (i.e. vertical degree of freedom):

$$F_f = 2K_f(L_f\theta - (z+h)) + 2C_f(L_f\dot{\theta} - \dot{z})$$

where:

$F_f, F_r =$ upward force on body from front/rear suspension

$K_f, K_r =$ front and rear suspension spring constant

$C_f, C_r =$ front and rear suspension damping rate

$L_f, L_r =$ horizontal distance from gravity center to front/rear suspension

$\theta, \dot{\theta} =$ pitch (rotational) angle and its rate of change

$z, \dot{z} =$ bounce (vertical) distance and its rate of change

$h =$ road height

Equations 2 describe pitch moments due to the suspension.

$$M_f = -L_f F_f$$

$$F_r = -2K_r(L_r\theta + (z+h)) - 2C_r(L_r\dot{\theta} + \dot{z})$$

$$M_r = L_r F_r$$

where:

$$M_f, M_r = \text{ Pitch moment due to front/rear suspension}$$

Equations 3 resolves the forces and moments result in body motion, according to Newton's Second Law:

$$m_b\ddot{z} = F_f + F_r - m_b g$$

$$I_{yy}\ddot{\theta} = M_f + M_r + M_y$$

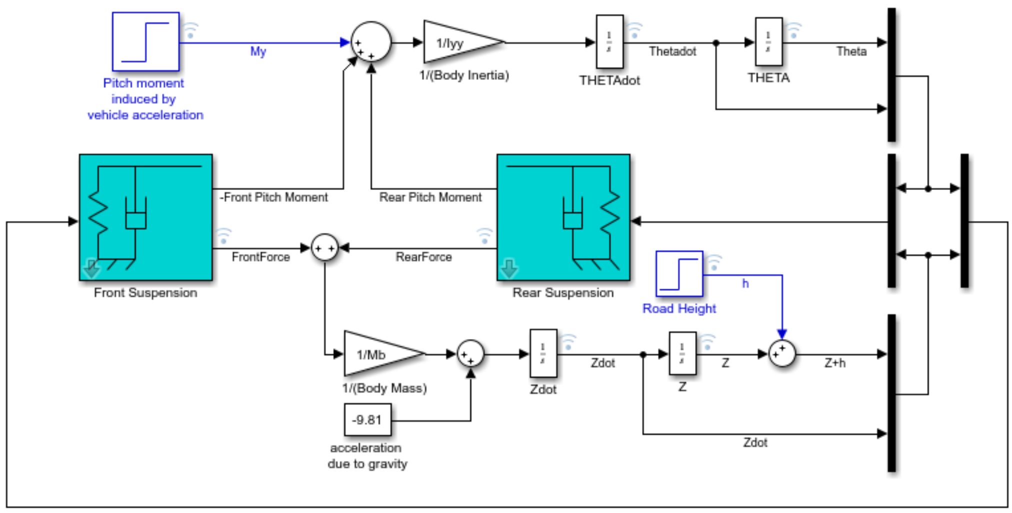
where:

$$m_b = \text{ body mass}$$

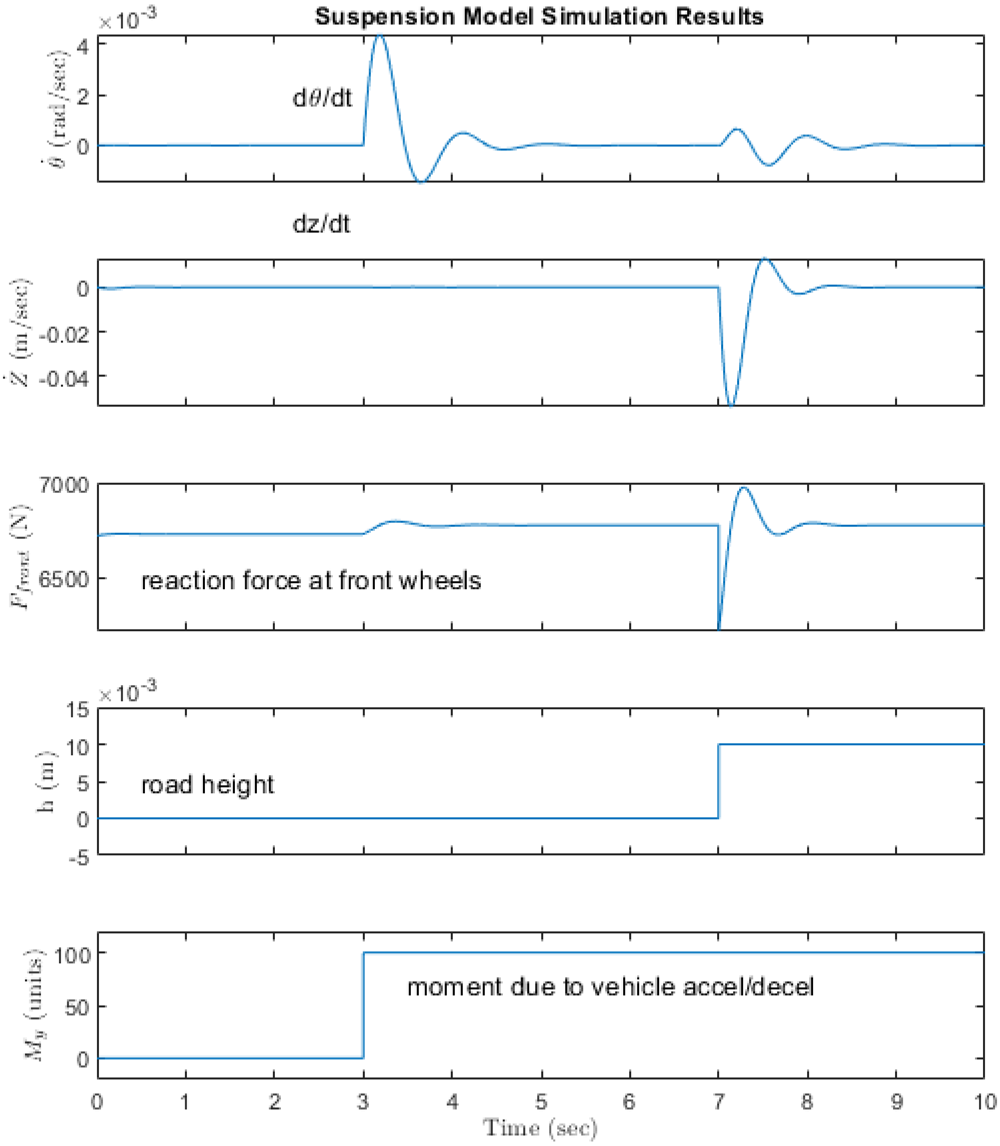
$$M_y = \text{ pitch moment induced by vehicle acceleration}$$

$$I_{yy} = \text{ body moment of inertia about gravity center}$$

Vehicle Suspension Model



Outputs:



Conclusion:

This model allows you to simulate the effects of changing the suspension damping and stiffness, thereby investigating the tradeoff between comfort and performance. In general, racing cars have very stiff springs with a high damping factor, whereas passenger vehicles have softer springs and a more oscillatory response.