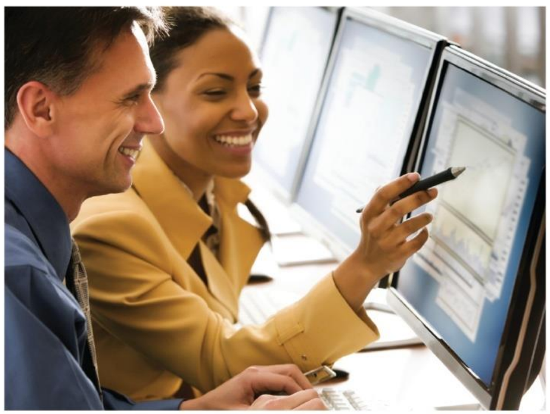
Exercises: Design Optimization

Physical Modeling for Formula Student



Passive Suspension Optimization

Try

```
>> passiveSuspOpt
```

Task: Optimize the stiffness and damping coefficients of a passive suspension mechanism to be within required bounds during a drop test.

Steps:

1. Open the model `passiveSuspOpt`. Then, start a response optimization task.

2. Add the following variables as design parameters.

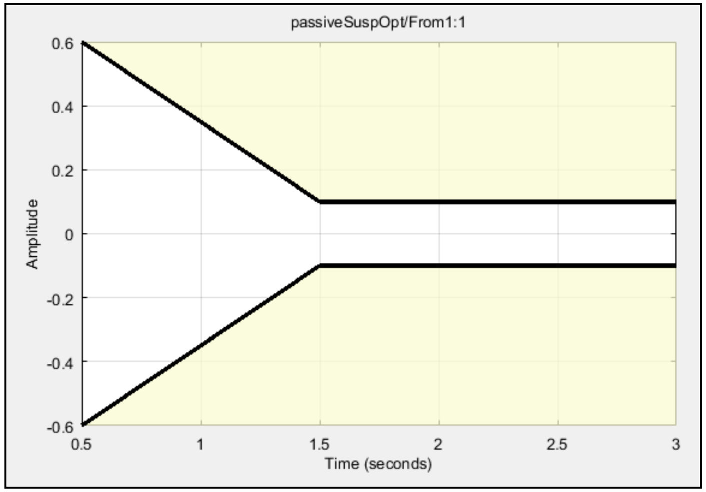
   - Stiffness coefficient, `Ks`:
     Minimum value: `0`, Maximum value: `5e6`

   - Damping coefficient, `Ds`:
     Minimum value: `0`, Maximum value: `1e5`

3. Create the bounds for the `camber_left` signal as shown on the right. Note that you can do this by creating the upper and lower bounds separately and displaying them on the same plot.

4. Run the optimization task with default settings. You may find that the results are close to the lower bound. Try changing the optimization options (in particular, the optimization algorithm) to improve results.

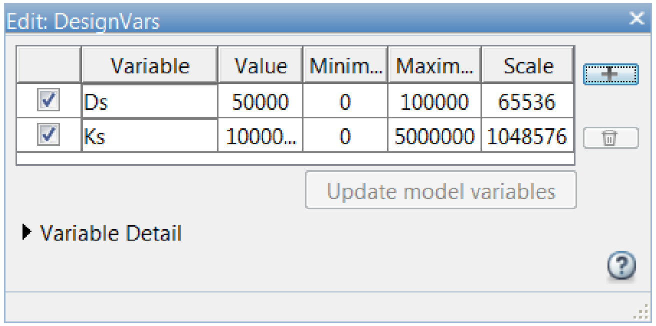
`(0.5,0.6)` `(1.5,0.1)` `(3,0.1)`



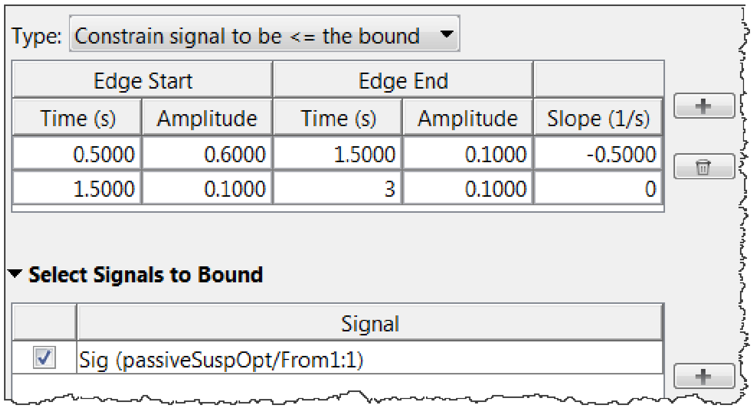
`(0.5,-0.6)` `(1.5,-0.1)` `(3,-0.1)`

Solution: Passive Suspension Optimization

1. Set up the design variables as follows.



2. Create two separate **Signal Bound** requirements for the upper and lower bounds. The upper bound requirement is shown below.

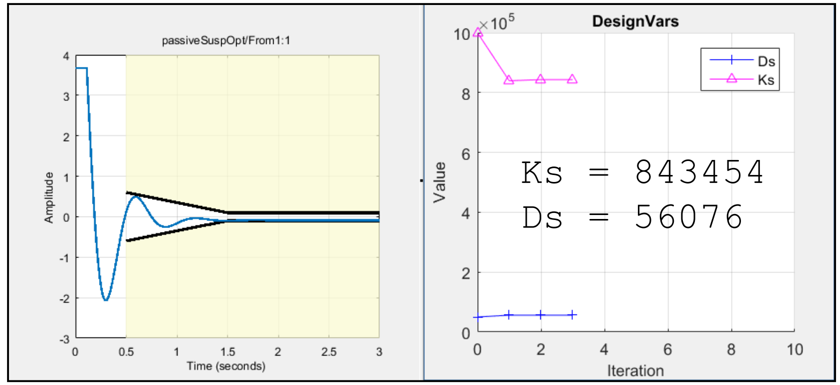


The lower bound should look similar, except all the amplitude values are negative and the **Type** should be `Constrain signal to be >= the bound`.

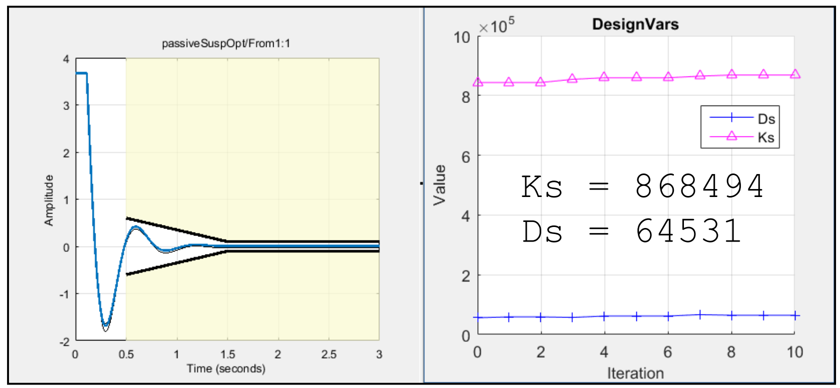
Try

Start a new response optimization task and load a solution session from the `passiveSuspOpt_session.mat` file.

3. If you run the optimization with default settings, you will see the following results. Note that the camber is close to the lower bound.



Try changing the optimization **Method** to `Simplex search` and resuming the optimization from the previous results. After 10 iterations, the system response will be as shown below.



Active Suspension Optimization

Try

```
>> activeSuspOpt
```

Task: Optimize the controller gains and pump throttle of a hydraulically actuated active suspension mechanism to meet performance requirements.

Steps:

1. Open the model `activeSuspOpt`. Then, start a response optimization task.

2. Add the following variables as design parameters.

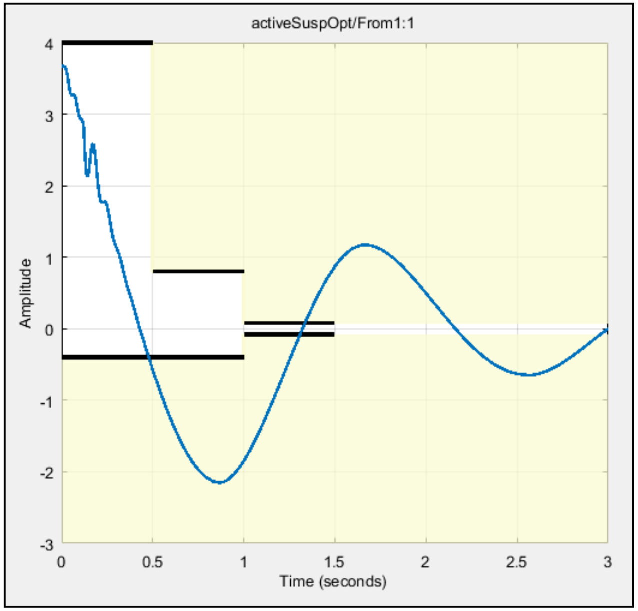
   - Proportional controller gain, `Kp`:
     Minimum value: `0`, Maximum value: `1`

   - Integral controller gain, `Ki`:
     Minimum value: `0`, Maximum value: `20`

   - Pump throttle, `pumpThrottle`:
     Minimum value: `0`, Maximum value: `1`
     Note A full throttle of 1 drives the pump at 2000 RPM.

3. Create a new **Step Response Envelope** requirement for the `camber_left` signal as shown on the right.

4. Run the optimization task with default settings and find the final design parameter values.

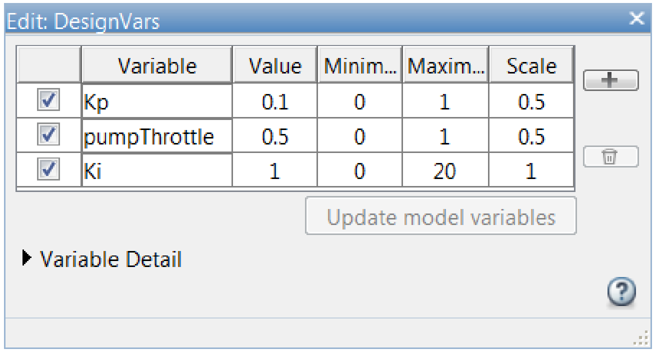


Step Response Parameters:

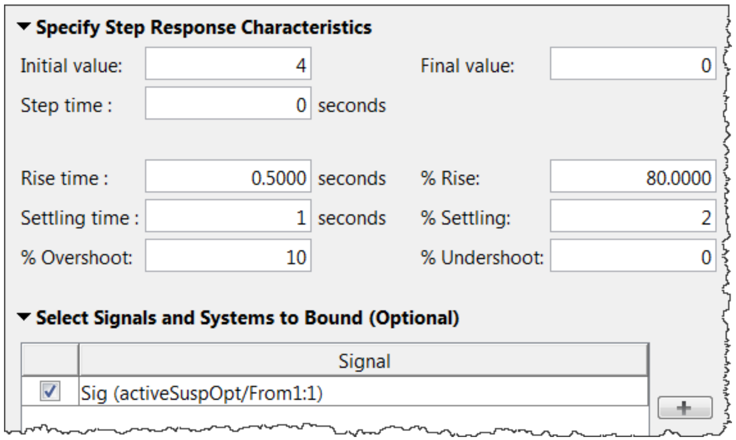
Initial camber value:	4°
Final camber value:	0°
Step time:	0 s
Rise time:	0.5 s
% Rise:	80%
Settling time:	1 s
% Settling:	2%
Overshoot:	10%
Undershoot:	0%

Solution: Active Suspension Optimization

1. Set up the design variables as follows.



2. Create a **Step Response Envelope** requirement as shown below.



Try

Start a new response optimization task and load a solution session from the `activeSuspOpt_session.mat` file.

3. After five iterations, the optimization results are approximately
   - `Kp = 1`
   - `Ki = 0.002`
   - `pumpThrottle = 0.155` (310 RPM)