

Altair MotionView 2019 Tutorials

MV-3023: Optimization of a Suspension

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MV-3023: Optimization of a Suspension

In this tutorial you will learn how to setup an optimization problem using MotionView's Optimization Wizard for a suspension model. This model is taken from MotionView tutorial MV-3010. You will learn about:

- Defining point coordinates as design variables
- Defining a response type 'Root Mean Square Deviation' for matching curve
- Using the responses as objectives
- Running the optimization and comparing the results in HyperGraph

Introduction

In this tutorial, you will reproduce the suspension optimization problem in MV-3010 (Optimization using MotionView - HyperStudy). The location (y and z coordinates) of both inner tie-rod ball joint and outer tie-rod ball joint are changed so that the toe vs. ride height curve matchs a given desired target curve.





Suspension Topology to Optimize



'Toe-ride height' curve of initial design, optimized design and target design

You can compare the difference between MotionSolve optimization and MotionView + HyperStudy optimization and learn the benefits of each method.



Model Setup

Copy the file mv_3023_initial_susp_opt.mdl and target_toe.csv located in the mbd modeling\motionsolve\optimization\MV-3023 into your <working directory>.

Step 1: Adding Design Variables.

- 1. Open mv_3023_initial_susp_opt.mdl in MotionView.
- 2. Right-click on *Model* in the browser and launch the **Optimization Wizard**.
- 3. Under **Design Variable**, click on the **Points** tab.

All points listed are shown below.

- 4. Make the y and z coordinates of inner tie-rod ball joint and outer tie-rod ball joint designable.
 - a. Go to point **Otr tierod ball jt left** under the **Frnt SLA susp (1 pc LCA)** system. Expand the data member of it and select y and z. Click *Add*.
 - b. Similarly, add y and z data members of point **Inr tierod ball left** under the **Parallel steering** system.
 - c. Change the upper and lower bound of Dvs based on the table below.

DV	Lower Limit	Upper Limit
Otr tierod ball jt(DV)-left-y	-651.15	-551.15
Otr tierod ball jt(DV)-left-z	190.92	250.92
Inr tierod ball(DV)-left-y	-298.9	-209.9
Inr tierod ball(DV)-left-z	230.86	278.86



TOptimization Wizard													×
ptimization Study	Points(4)	Bodies(0)	Springs(0)	Bushing(0)	Forces(0)	Datase	ets(0)						
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X Goals	B B	ody fixed to gro Vehicle Borh	und CG		г	10010	dv9	Otr tierod ball jt(DV)-left-z	190.9200	248.9200	250.9200	3	
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Optimization Wizard after creating design variables

Now, the Response Variables can be added.

Step 2: Adding Response Variables.

The objective of the optimization is to make the toe vs. ride height curve match a target design. The model already has the desired target curve defined and it will be used in the response being created.

- 1. Go to the **Responses** page. Add a response variable using the \ddagger button.
- 2. In the response variable panel that appears choose **Response Type**, **Root Mean Square Deviation**.

This response needs three inputs from the user:

- Desired Curve This is the target curve.
- Response Expression This is the value we measure.
- Independent Variable This defines the independent variable used to calculate the target value.
- 3. Choose '*toe_rh*' for **Desired Curve** by clicking on the *Curve* button.
- 4. Activate the **Specify independent variable** check box. Select SoverVariable **toe_angle** by clicking **SolverVariable**.



5. For **Response Expression**, type in the expression for ride height:

`(DZ({MODEL.sys_frnt_susp.b_wheel.l.cm.idstring})-282.57)`

This completes the creation of the response. The user interface should appear as shown below.

💙 Optimization Wizard			×
Optimization Study	Lobel Model 1 - Response Venable 0 (vv_0)		
	× ✓ .f. Data Layout Response type: Root Mean Square Deviation ▼ Label: Response/Variable 0 F	Desired Curve: Curve toe_th Show desired curve P Specify independent variable SolverVariable toe_angle Response Expression: (D2(10401010)-082.57)	

Optimization Wizard after creating response variable



Step 3: Adding Objectives and Constraints.

The problem has only one objective: matching the toe-ride height curve with the target design.

We can add responses that have been created in the previous section as objectives.

- 1. Go to the **Goals** page. There are two sections: **Objectives** and **Constraints**.
- 2. Click on the 🕈 button under **Objectives**.

An objective is added with response **rv_0**.

The model setup is now complete and it is ready to be run.



Defining objectives



Step 4: Running the Optimization.

In the Solution page, we can specify optimization settings and run the analysis. Please note that the model is saved before running, and if you do not want the optimization settings to be saved in the model, you can choose to save an mdl file in a different name before starting the optimization. This can be done by closing the wizard, saving the model with a different name and returning to the Solution page of the wizard.

1. Click on *Save & Optimize* to run the optimization.

Optimization Settings X ↓ / A Output File: C \Users\Tutorials\Optimization Simulation type: Ouesi-static End time: 4 0000 Print interval: 0.0400	n/mv_3023_intel_susp_c Simulation Settings Output Options	Optimization Settings		
		 The open scenario community 		Seve & Optimize
17 46 3.2 18 48 1.4 Optimization terminated suc Results from Optimization Initial Cost = 6508.020 Final Cost = 0.014 Cost reduction = 100.000 Individual Responses Weight = 1.00 Final cost of Final Design Table	625e-02 3. 065e-02 7. cessfully.	.6932e+00 .8054e-02 EL_rv_0 = 1.4065e-02		
pv sys_frnt_susp.p.otrb.1.y sys_frnt_susp.p.otrb.1.z sys_steering.p_itrb.1.y sys_steering.p_itrb.1.z Elapsed Time for job Time in Cost function Time in Sensitivity funct Optimization process comple motionsolve:: Solver run fi	Lower Bound -6.5115e+02 +1.9092e+02 +2.9890e+02 +2.3086e+02 ion ted. nished after 96	Upper Bound -5.5115e+02 +2.5092e+02 +2.7886e+02 = 69.73 seconds = 38.94 seconds = 27.24 seconds 8 seconds.	Initial Value -5.6515e+02 +2.4892e+02 -2.1590e+02 +2.7686e+02	Optimized Value -6.3200e+02 +2.0448e+02 -2.9613e+02 +2.3824e+02
	17 46 3.2 18 49 1.4 Optimization terminated success Results from Optimization 	17 46 3.2625e-02 3 18 48 1.4065e-02 7 Optimization terminated successfully. Results from Optimization 7 Initial Cost = 6508.020 Final Cost = 0.014 7 Cost reduction = 100.000 Individual Responses 7	17 46 3.2625e-02 3.6932e+00 18 48 1.4065e-02 7.8054e-02 Optimization terminated successfully. Results from Optimization	17 46 3.2625e-02 3.6932e+00 18 48 1.4065e-02 7.8054e-02 Optimization terminated successfully. Results from Optimization

Solution Settings



Step 5: Post-processing

1. Once the optimization process is complete, review the result by clicking on **Review Results** page. The summary window should look like the following:

	Summary Piot Animat	and the second				
Design Variables Responses	Type: ALL		Iteration	sys_fmt_susp.p_otrb.l.y	sys_fmt_susp.p_otrb.l.z	sys_steering.p
Goals	sys_fmt_susp.p_ot/b.l.y	- I	Initial Design	-565.1500	248.9200	-215.900
Solution	sys_steering.p_itb.ly		1	-561.6076	234.2444	-236.901
Review Results	sys_steering.p_itb.l.z Overall Objective		2	-555.0416	225.1119	-260.307
	Obj-1 MODEL_rv_0		3	-554.5031	222.7957	-265.64
		1	4	-554.1068	221.2903	-269.57
		1	5	-553.8049	220.2361	-272.57
		1	6	-557.0795	223.2964	-266.1%
			7	-562.6337	226.0587	-260.56
		1	8	-570.5730	228.4460	-255.49
		1	9	-570.9974	229.2877	-254.10
		1	10	-573.2652	228.1858	-255.84
			11	-573.7217	228.5499	-255.30
			12	-574.6178	227.9968	-256.20
		->	13	-578.6297	225.9693	-259.55
			14	-583.8135	223.7458	-263.27
		1	15	-613.2690	211.6561	-283.70
			16	-633.7281	203.7470	-297.35
		1	17	-631.0950	204.8579	-295.49
		1	18	-631.9976	204.4819	-296.13

Optimization Summary of MV-3010

- 2. You can also review the plots and animation by going to the **Plot** and **Animation** pages as we demonstrated in previous tutorials. For this optimization, it is worthwhile to plot the toe ride height curve for different iterations and see how the curve approaches the target one.
 - a) Close the Optimization Wizard.
 - b) Add an HyperGraph page to the session.
 - c) Open the file target_toe.csv.
 - d) In the plotting panel, change the 'type', 'request' and 'component' of both x and y as follows:

t	Data Ne:	1	C:\Users\yzhu\PychamProjects\ADW\MV mode	fs\Tutorial 4 - MV 3010/target_toe.cov					•	Apply
1	Subcase:	-	÷	Y Type: th. IF the	Filter	YRequest The IF THE	Filter:	Y Component The UP THE	Filter:	Preview
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	×Comp	onent	÷ Toe angle •							
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Settings to plot target curve

You should see a straight line in the plotting window.



- 3. Next, go to the subfolder **initial design** and load the mrf file in it.
- 4. Change the 'type', 'request' and 'component' of both x and y as follows:

Data Her:	C:Wsers/yzh/APychamProjects/ADW/MV no	dels/Tutorial 4 - MV 3010/urw3010_final_2	11452/initial_design/mv3010_final	mf			1	 Apply
Subcase:	÷	Y Type: The UP Ite	Filter.	Y Request <u>t⊨ ⊥≓ </u> 1≣	Filec	Y Component The LT THE	Filter	E Preview
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×Request	* RE0/70000033 toe-curve	Expressions Sustem		REQ/70000033 foe-curve		F2		Adv. Options
× Component	÷ F2	 MSInternal 				F4		•
Layout	Use current plot	•		Al	None Flip		All None Flip	·

Settings to plot initial design

- 5. Click *Apply* and you should see a convex curve representing the 'toe-ride height' of the initial design.
- 6. Now, go to the subfolder 'iter-18' (the last iteration).
- 7. Import the mrf file and plot the curve with the same setting.
- 8. The 'toe-ride height' curve of optimized design overlaps with the target curve.



Target curve, initial design and optimized design of MV-3010

