# DYNATUNE SUSPENSION DESIGN MODULE "EXPERT" VERSION - RELEASE 8.1

Copyright
DYNATUNE-XL

BLUE = ENTER / SELECT DATA

BLUE = ENTER ELSEWHERE - DO NOT TOUCH

NOTE: PLEASE DO INSTALL MICROSOFT SOLVER` ADD-IN IN EXCEL PRIOR TO USING THIS FEATURE

Sensitivity & Optimization Process

Results

## GEOMETRY & STIFFNESS DATA

Number of "Combined/Superimposed" Joints: Inboard 0 | 2 Outboard

All Partecipating Joints follow the Changes of 1 Joint

| Link ID Nr. | LINK DESCRIPTION | X [mm] | Y [mm] | Z [mm] | Stiffness [N/mm] |
|---|---|---|---|---|---|
| 1 | Track Rod @ Chassis Joint | 115.000 | 145.000 | 410.000 | 10000 |
| 2 | Track Rod @ Wheel Joint | 60.000 | 625.000 | 412.000 | |
| 3 | Spring Link @ Chassis Joint | -290.000 | 190.000 | 210.000 | 10000 |
| 4 | Spring Link @ Wheel Joint | 10.000 | 650.000 | 200.000 | |
| 5 | Lower Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | 150.000 | 55.000 | 195.000 | 10000 |
| 6 | Lower Link 2 @ Wheel Joint | 10.000 | 650.000 | 200.000 | |
| 7 | Upper Link 1 @ Chassis Joint | 75.000 | 200.000 | 410.000 | 10000 |
| 8 | Upper Link 1 @ Wheel Joint | -15.000 | 620.000 | 410.000 | |
| 9 | Upper Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | -265.000 | 225.000 | 405.000 | 10000 |
| 10 | Upper Link 2 @ Wheel Joint | -15.000 | 620.000 | 410.000 | |
| 11 | Spring/Damper@ Chassis Joint | -370.000 | 100.000 | 580.000 | |
| 12 | Spring/Damper @ Rocker Joint | -175.000 | 50.000 | 585.000 | |
| WC | Wheel Center Point | 0.000 | 715.000 | 320.000 | |
| WC ALIGN | Calculated Wheel Center Alignment Point | 0.000 | 615.000 | 320.000 | 100.000 |
| CP | Calculated Contact Patch | 0.000 | 715.000 | 0.000 | |

| Var. X-Range [mm] | Var. Y-Range [mm] | Var. Z-Range [mm] | Var. Stiffness Range [%] |
|---|---|---|---|
| 10.000 | 10.000 | 10.000 | 50% |
| X [mm] | Y [mm] | Z [mm] | Stiffness [N/mm] |
| 10.00 | 10.00 | 10.00 | 5000.000 |
| 10.00 | 10.00 | 10.00 | |
| 10.00 | 10.00 | 10.00 | 5000.000 |
| 10.00 | 10.00 | 10.00 | |
| 10.00 | 10.00 | 10.00 | 5000.000 |
| 10.00 | 10.00 | 10.00 | |
| 10.00 | 10.00 | 10.00 | 5000.000 |
| 10.00 | 10.00 | 10.00 | |
| 10.00 | 10.00 | 10.00 | 5000.000 |
| 10.00 | 10.00 | 10.00 | |

STEP 1 MANDATORY
PREPARE OPTIMIZATION EVENT & LOAD SUSPENSION DATA

## OPTIMIZATION CONTROL PANEL

STATIC SUSPENSION SYSTEM PARAMETERS

| Include Static Suspension System Parameters in Kinematic Analysis | Bump Steer [°/m] | Camber Gain [°/m] | Roll Center Height [mm] | Roll Center Height Movement / Wheel Travel Ratio [-] | Wheel Center Anti-Angle [°] | Contact Patch Anti-Angle [°] |
|---|---|---|---|---|---|---|
| REFERENCE START VALUES @ STEP 1 | -1.00 | -10.00 | 10.02 | 0.935 | -1.00 | -5.00 |
| NEW TARGET VALUE | -1.000 | -10.000 | 10.000 | 1.000 | -1.000 | -5.000 |
| IMPORTANCE / WEIGHT - 0 to 10 [0 = Deactivated] | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| NEW TARGET PREDICTION | 2.0864 | -1.0050 | 2.4740 | 0.9855 | -0.5196 | -4.6804 |

Kinematic "Suspension" System Performance Index: 102.11

Delta < 2%
2% < Delta <10%
Delta > 10%

Carefully Select Parameters for Rear Suspension or Deactivate Partially/Completely

STATIC STEERING SYSTEM PARAMETERS

| Include Static Steering System Parameters in Kinematic Analysis | Caster [°] | Caster Trail [mm] | Caster Off. [mm] | KPI [°] | KPI Off. [mm] | Scrub Radius [mm] |
|---|---|---|---|---|---|---|
| REFERENCE START VALUES @ STEP 1 | 7.13 | 35.00 | -5.00 | 11.48 | 75.00 | 10.02 |
| NEW TARGET VALUE | 7.000 | 35.000 | -5.000 | 11.000 | 75.000 | 10.000 |
| IMPORTANCE / WEIGHT - 0 to 10 [0 = Deactivated] | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| NEW TARGET PREDICTION | 6.7890 | 33.8100 | -4.2860 | 8.1300 | 82.1430 | 36.4290 |

Kinematic "Steering" System Performance Index: 192.79

Elasto-Kinematic Performance Index: 0.00

(Geometric) Compliance Effects shoould be analyzed only at the End of Optimization!

STATIC ELASTO-KINEMATIC SYSTEM PARAMETERS

| Include Link Stiffness Parameters in Compliance Analysis | Toe [°/kN] | Toe [°/kN] | Toe [°/kN] | Toe [°/kN] | Camber [°/kN] | Toe [°/kNm] |
|---|---|---|---|---|---|---|
| Include Geometric Effects in Results of Compliance Analysis (ONLY FOR EXPERTS) | Long. Braking Load @ CP | Long. Acceleration Load @ WC | Lat. Load @ Out. Wheel @ CP WITHOUT Pneum. Trail | Lateral Load @ Out. Wheel @ CP WITH Pneumatic Trail | Lateral Load @ Out. Wheel @ CP WITH Pneumatic Trail | Aligning Torque @ CP |
| REFERENCE START VALUES @ STEP 1 | -0.135 | 0.114 | -0.008 | -0.046 | 0.044 | 1.856 |
| NEW TARGET VALUE | -0.020 | 0.010 | -0.030 | 0.000 | 0.050 | 0.700 |
| IMPORTANCE / WEIGHT - 0 to 10 [0 = Deactivated] | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| NEW TARGET PREDICTION | | | | | | |

Delta < 0.01
0.01 < Delta < 0.02
Delta > 0.02

Overall Suspension Performance Index: 294.89

| Optimization Geometry & Link Stiffness Design Space | GEOMETRY x | y | z | STIFFNESS Link 1 - 2 | Link 3 - 4 | Link 5 - 6 | Link 7 - 8 | Link 9 - 10 |
|---|---|---|---|---|---|---|---|---|
| Delta Hardpoint and Link Stiffness Minimum Values [mm] - [N/mm] | -25.0 | -25.0 | -25.0 | 5000.0 | 5000.0 | 5000.0 | 5000.0 | 5000.0 |
| Delta Hardpoint and Link Stiffness Maximum Values Value [mm] - [N/mm] | 25.0 | 25.0 | 25.0 | 15000.0 | 15000.0 | 15000.0 | 15000.0 | 15000.0 |

Note: Going outside the Initially Selected Variance Numbers of the Sensitivity Study is allowed, but can/will make the Prediction Model less accurate accurate and require more manual loops.

STEP 1 MANDATORY
PREPARE OPTIMIZATION EVENT & LOAD SUSPENSION DATA FROM MASTER DASHBOARD

STEP 2
RUN SENSITIVITY ANALYSIS

STEP 3
START / RESET OPTIMIZATION

STEP 4
CONTINUE / RUN OPTIMIZATION

STEP 5
SET OPTIMIZED DATA AS NEW STARTING POINT

RUN FULLY AUTOMATIC STEP 3, STEP 4 & STEP 5 OPTIMIZATION LOOP

EXECUTE FULL AUTOMATIC SENSITIVY ANALYSIS & OPTIMIZATION LOOP (s) WITH FINAL VERIFICATION RUN

STEP 6
COPY NEW / OPTIMIZED DATA TO MASTER DASHBOARD

Number of Full Optimization Loops: 6

RESET ALL SUSPENSION DATA BACK TO ORIGINAL "STEP 1" LOADING CONDITION

## NEW / OPTIMIZED GEOMETRY & STIFFNESS DATA

| Joint ID Nr. | LINK DESCRIPTION | X [mm] | Y [mm] | Z [mm] | Stiffness [N/mm] |
|---|---|---|---|---|---|
| -1 | Track Rod @ Chassis Joint | 115.000 | 145.000 | 410.000 | 10000 |
| 2 | Track Rod @ Wheel Joint | 60.000 | 625.000 | 412.000 | |
| 3 | Spring Link @ Chassis Joint | -290.000 | 190.000 | 210.000 | 10000 |
| 4 | Spring Link @ Wheel Joint | 10.000 | 650.000 | 200.000 | |
| 5 | Lower Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | 150.000 | 55.000 | 195.000 | 10000 |
| 6 | Lower Link 2 @ Wheel Joint | 10.000 | 650.000 | 200.000 | |
| 7 | Upper Link 1 @ Chassis Joint | 75.000 | 200.000 | 410.000 | 10000 |
| 8 | Upper Link 1 @ Wheel Joint | -15.000 | 620.000 | 410.000 | |
| 9 | Upper Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | -265.000 | 225.000 | 405.000 | 10000 |
| 10 | Upper Link 2 @ Wheel Joint | -15.000 | 620.000 | 410.000 | |
| 11 | Spring/Damper@ Chassis Joint | -370.000 | 100.000 | 580.000 | |
| 12 | Spring/Damper @ Rocker Joint | -175.000 | 50.000 | 585.000 | |
| WC | Wheel Center Point | 0.000 | 715.000 | 320.000 | |
| WC ALIGN | Calculated Wheel Center Alignment Point | 0.000 | 615.000 | 320.000 | 100.000 |
| CP | Calculated Contact Patch | 0.000 | 715.000 | 0.000 | |

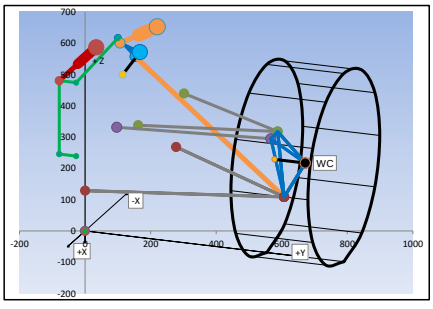
## X-Y-Z Coordinates Variance to be Included / Excluded in Analysis

| Joint ID Nr. | Include X [1/0] | Include Y [1/0] | Include Z [1/0] |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 |
| 9 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 |

STEP 6
COPY NEW / OPTIMIZED DATA TO MASTER DASHBOARD

## DELTA VALUES FROM "STEP 1" LOADED DATA SET

| Link ID Nr. | LINK DESCRIPTION | X [mm] | Y [mm] | Z [mm] | Stiffness [N/mm] |
|---|---|---|---|---|---|
| -1 | Track Rod @ Chassis Joint | 0.000 | 0.000 | 0.000 | 0 |
| 2 | Track Rod @ Wheel Joint | 0.000 | 0.000 | 0.000 | |
| 3 | Spring Link @ Chassis Joint | 0.000 | 0.000 | 0.000 | 0 |
| 4 | Spring Link @ Wheel Joint | 0.000 | 0.000 | 0.000 | |
| 5 | Lower Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | 0.000 | 0.000 | 0.000 | 0 |
| 6 | Lower Link 2 @ Wheel Joint | 0.000 | 0.000 | 0.000 | |
| 7 | Upper Link 1 @ Chassis Joint | 0.000 | 0.000 | 0.000 | 0 |
| 8 | Upper Link 1 @ Wheel Joint | 0.000 | 0.000 | 0.000 | |
| 9 | Upper Link 2 (or 2nd A-Arm Leg) @ Chassis Joint | 0.000 | 0.000 | 0.000 | 0 |
| 10 | Upper Link 2 @ Wheel Joint | 0.000 | 0.000 | 0.000 | |
| 11 | Spring/Damper@ Chassis Joint | 0.000 | 0.000 | 0.000 | |
| 12 | Spring/Damper @ Rocker Joint | 0.000 | 0.000 | 0.000 | |
| WC | Wheel Center Point | 0.000 | 0.000 | 0.000 | |
| WC ALIGN | Calculated Wheel Center Alignment Point | 0.000 | 0.000 | 0.000 | 0.000 |
| CP | Calculated Contact Patch | 0.000 | 0.000 | 0.000 | |

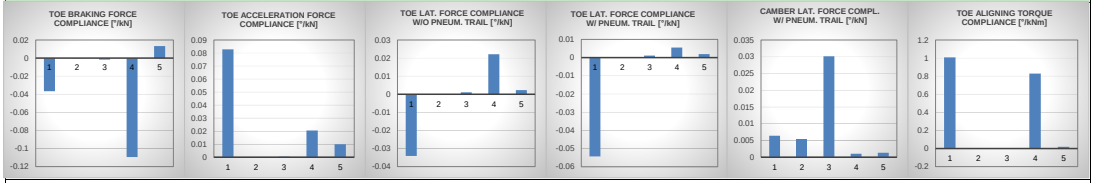


## *PARAMETER SENSITIVITY STUDY*

THE FOLLOWING CHARTS SHOW SUSPENSION PARAMETER SENSTIVITY - **DELTA VALUES** - TO THE SELECTED VARIANCE OF GEOMETRIC X,Y,Z COORDINATES & LINK STIFFNESS VALUES.

### SENSITIVITY (DELTA VALUE) TO GEOMETRIC HARDPOINT VARIANCE OF JOINT 1 TO 12

### SENSITIVITY (DELTA VALUES) TO STIFFNESS VARIANCE FOR LINK 1 TO 5




THE FOLLOWING CHARTS SHOW SUSPENSION PARAMETER SENSTIVITY - **NOMINAL VALUES** - TO THE SELECTED VARIANCE OF GEOMETRIC X,Y,Z COORDINATES & LINK STIFFNESS VALUES.

### SENSITIVITY (NOM. VALUE) TO GEOMETRIC HARDPOINT VARIANCE OF JOINT 1 TO 12

### SENSITIVITY (NOM. VALUES) TO STIFFNESS VARIANCE FOR LINK 1 TO 5