

Suspension Analyzer

Full Vehicle Version

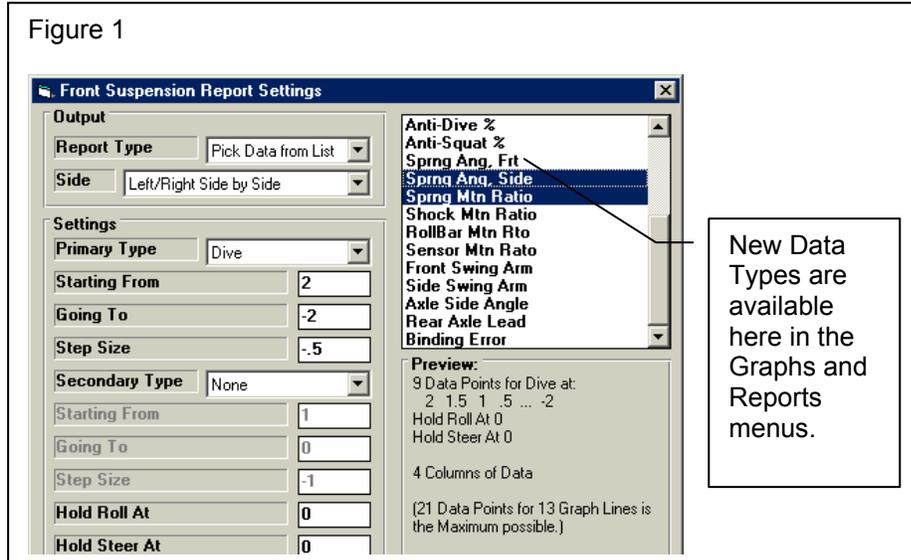
Overview of Features

The Full Vehicle version of Suspension Analyzer has several enhancements over the standard version, the most significant is analyzing various types of rear suspensions and combining front and rear suspensions together for full vehicle analysis. A list of the Full Vehicle version's features includes:

The Full Vehicle Version lets you graph or report these additional types of data.

Anti-Squat %	Sprng Ang, Frt	Sprng Ang, Side
Sprng Mtn Ratio	Shock Mtn Ratio	RollBar Mtn Rto
Sensor Mtn Rato	Front Swing Arm	Side Swing Arm
Axle Side Angle	Rear Axle Lead	Binding Error (for solid axles and 5 link independent)
FLLD% (front lateral load distribution, a handling rating)		

These data types are added to the bottom of the Data List in the Graph and Report menu.



These data are displayed on the Main Screen in the Data Grid. For a complete listing of these inputs and calculated outputs, click on Help at the top of the Main Screen, then List Definitions for Main Screen Input/Output.

The Full Vehicle Version lets you specify Push Rod w Rocker Arm and Pull Rod w Rocker Arm springs for Double A Arm suspensions. In Vehicle Specs, choose these types for the “Springs” spec.

Figure 2 Example of Pushrod Spring Layout

Suspension Analyzer v1.1 Performance Trends [pushrod]

File Edit Graphs Reports Vehicle Specs Adjust Optimize Zoom Animate Preferences Help

Front View Side View Top View No View Dynamic Dive Roll Steel

This is a view from the rear of car (right side of screen is actually right side of car).
Gain based on 1" Dive.

Front Suspension

Refresh

Toe-In Gain: .19" Roll Center Ht: .89 Turn Radius: None Roll Center Right: .00 Toe-In Gain: .19"
Camber Gain: -.34 Caster Gain: .49 Caster Gain: .49 Camber Gain: -.34

Suspension Data							
Location	Type	Lt Out (X)	Lt Height (Y)	Lt Depth (Z)	Rt Out (X)	Rt Height (Y)	Rt Depth (Z)
Spring Mount on Frame	Input	6	7	0	6	7	0
Push Rod Mount on Lower Arm	Input	18	8	0	18	8	0
Bellcrank Axis Front	Input	12	14	-10	12	18	-10
Bellcrank Axis Rear	Input	12	14	10	12	10	10
Spring Mount on Bellcrank	Input	9	18	3	9	18	3
Pushrod Mount on Bellcrank	Input	14	16	0	14	16	0
Spring Length	Output				11.79		
Spring Angle from Front	Output				-15.25		
Spring Angle from Side	Output				15.25		
Spring Rate/Wheel Rate	Input (clc)	400	180.1		400	244.8	

Bell Crank with rotation axis shown as circle here.

Pushrod attached to lower arm. Note that Pullrod would attach to the upper arm.

Enter measurements for Bell Crank and Pushrod or Pullrod here.

Full Vehicle Version lets you analyze these ends of the car.

Front Suspension Only	Rear Suspension Only
Front and Rear Suspension together	

Suspension Analyzer v1.1 Performance Trends [pushrod]

File Edit Graphs Reports Vehicle Specs Adjust Optimize Zoom Animate Preferences Help

Front View Side View Top View No View Dynamic Dive Roll Steel

This is a view from the rear of car (right side of screen is actually right side of car).
Gain based on 1" Dive.

Vehicle Specs

Back (ok) File Help

Vehicle Specs Front Suspension Rear Suspension

General Specs

Height of C.G., inches: 20 Calc

% Front Braking: 65

Wheelbase, inches: 100

Suspension to Analyze: Front and Rear

Vehicle Weights

Left Front: 562.5 Total Wt: 2500

Right Front: 687.5 Rear %: 50.0

Left Rear: 812.5 Left %: 55.0

Right Rear: 437.5 Cross %: 60.0

Calculate Corner Weights from %s

Identification

Chassis #: [dropdown]

Customer: [dropdown]

Comments

Stock 1978 Mustang II.
This is a popular front end for street rods.
Unfortunately we don't have spring or roll bar specs, just geometry. These are courtesy Bob McNall, Ford Engineer, street rod builder and good friend.

Help

Height of the vehicle's Center of Gravity. This measurement is only used for % Anti-Dive calculations. If you are not sure, use 20 inches. Click on the Calc Button to calculate from readings made during a special test. (See the manual on page 76.) p 20

Front Suspension

Rear Suspension

Refresh

Height (Y)	Rt Depth (Z)
08	.25
29	-2.23
54	2.7
9	0
9	0
32	10.27
19	-4.05
	-4.84
	0

Click on Vehicle Specs for the Menu Shown Here

Click these tabs to view specs (like Suspension Type) for Front or Rear of car.

Choose Which End to Analyzer here: Front only, Rear Only, or Front and Rear.

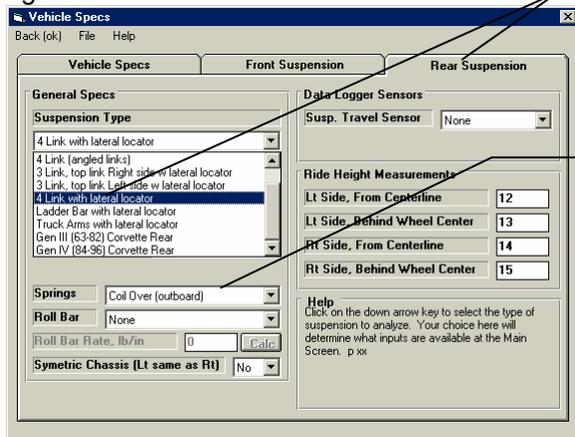
Click these buttons to work on, view and analyze the different ends of the car.

To graph or report data for a particular end of the car, you must have chosen to view that end of the car on the main screen by clicking on the appropriate button at the lower right of the layout screen.

The Rear Suspension Types supported at this time include are given below.

Double A Arm	McPhearson Strut
Three Link w panhard bar	Four Link (angled links like Chevelle or 5.0L Mustang)
Four Link w panhard bar	Ladder Bars (trailing arms)
NASCAR Truck Arms	C3 Corvette (63-82)
Torque Tube Live Axle	5 Link Independent (like C4 Corvette)
Torque Arm Live Axle	Trailing Arm and Semi Trailing Arm
Leaf Spring Live Axle	Decoupled (bird cage) Live Axle
	H Arm Independent (like IRS Thunderbirds and Cobra Mustangs)

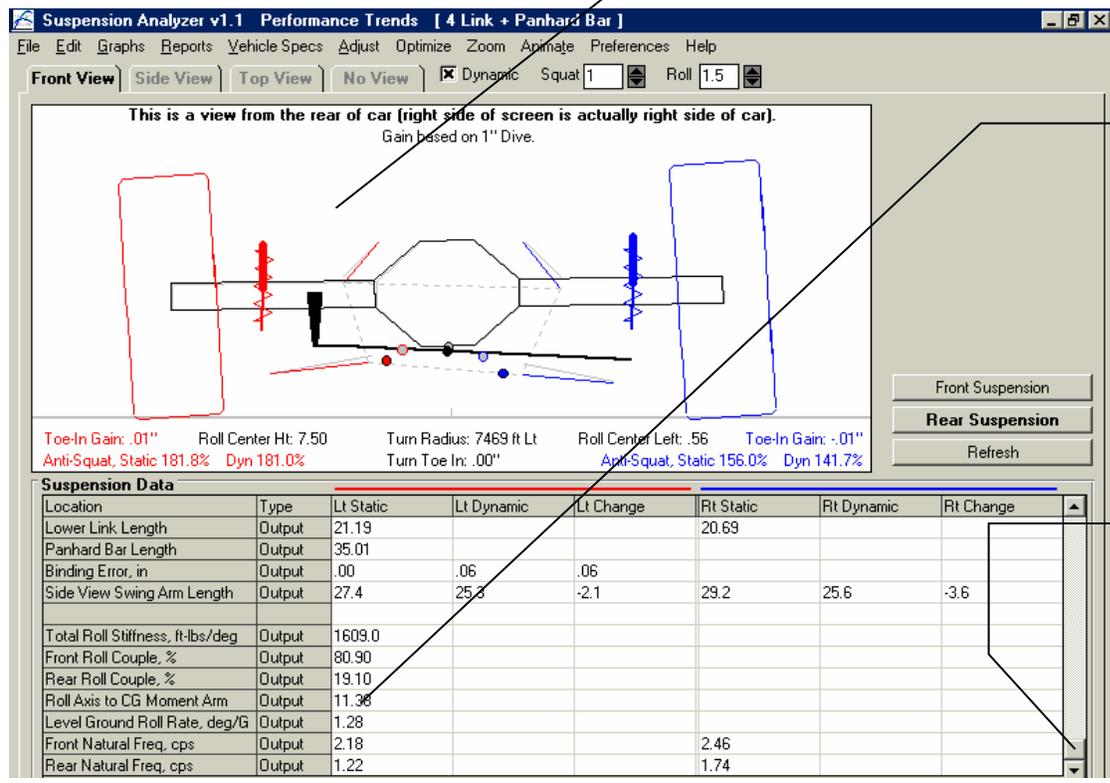
Figure 4



Click on the Rear Suspension tab to be able to choose the Rear Suspension Type from this list

Note that springs can be attached either to the lower arms or the axle housing itself. This can have a large affect on Spring Motion Ratio, Roll Stiffness and Front to Rear Roll Couple.

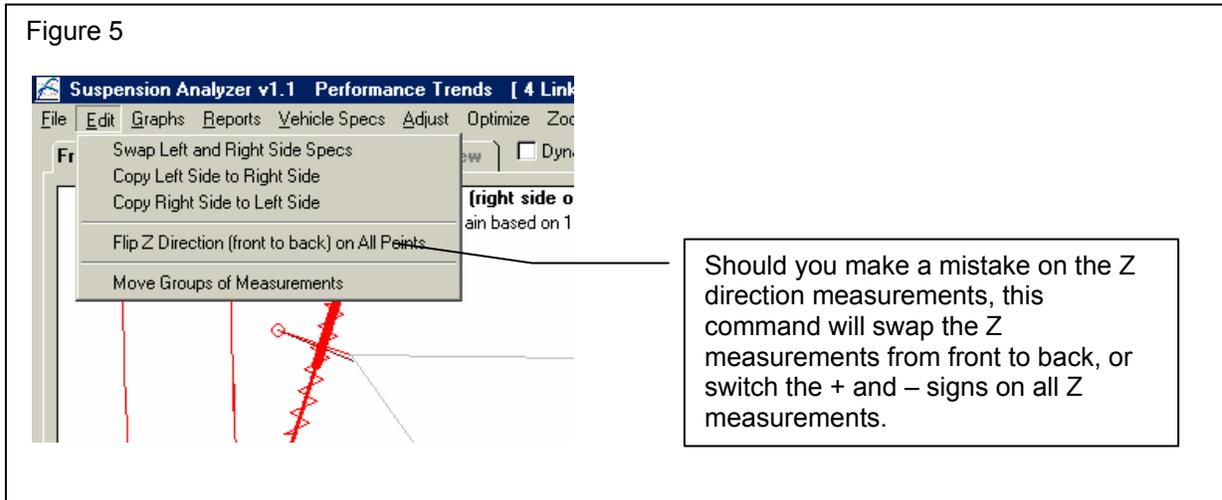
Layout view of 4 Link Rear Suspension with Panhard Bar



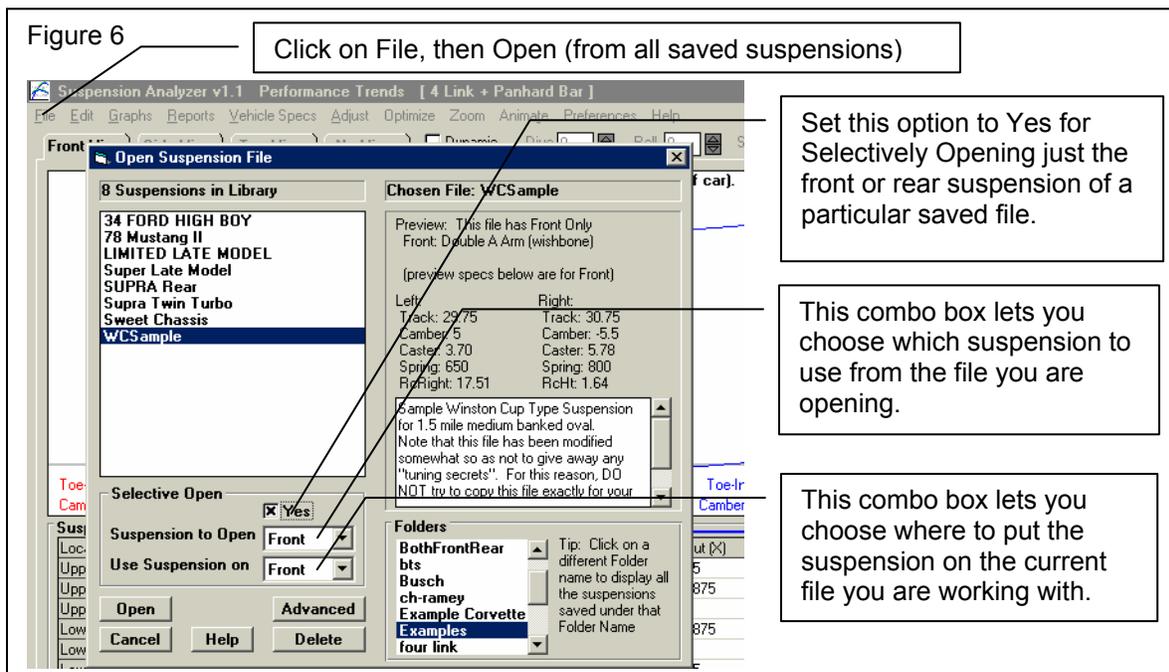
If you analyze Front and Rear Suspension together, the program also calculates and displays these Full Vehicle results. These results are listed at the bottom of the Data Table on the main screen.

Total Roll Stiffness, ft-lbs/deg	Front Roll Couple, % (a handling rating)
Rear Roll Couple, % (a handling rating)	Roll Axis to CG Moment Arm
Level Ground Roll Rate, deg/G	Front Natural Freq, cps
Rear Natural Freq, cps	FLLD% (front lateral load distribution, a handling rating)

The Depth (Z) measurements for Rear Suspensions are positive if they are in front of the axle, toward the front of the car. Depth (Z) for both the front and rear mean “in towards the center of the car”. See Figure 5 if you’ve made a mistake entering Z measurements.



Another useful feature for working with front and/or rear suspensions is the ability to “selectively open” one end of a vehicle suspension file and use it on the same end of the current vehicle you are working with or building. For example, say you have built a vehicle file working with only the Front Suspension file. Now you want to put only that front suspension on an existing vehicle file which has both a front and rear, but you want to keep the rear. You would click on File, then Open, then choose the Selective Open option shown in Figure 6. This feature also lets you put a front suspension on the rear or rear suspension on the front (McPhearson Strut or Double A Arm only).



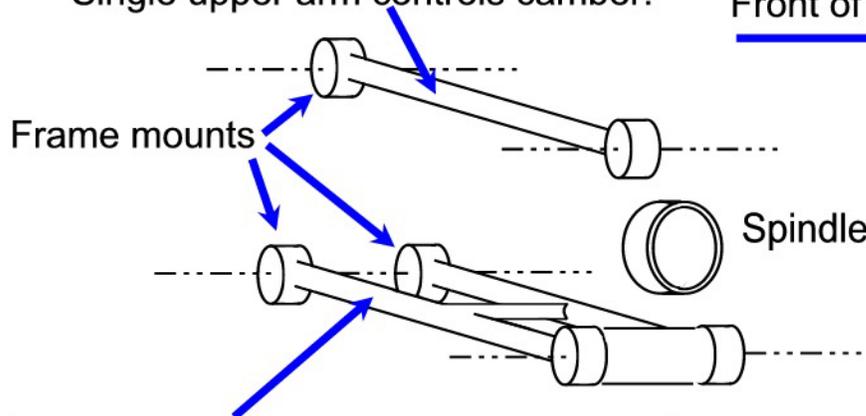
Version 1.1 C.017, Feb 4, 2002 added a new type of rear suspension type, the IRS with lower H arm, typical of that used in the IRS Ford Thunderbirds in 1987 and the Cobra Mustangs. See Figures 7 and 8 below.

Figure 7 Independent Rear Suspension (IRS) with Lower H Arm

Right Rear Suspension

Single upper arm controls camber.

Front of Vehicle 



Solid "H" arm mounts at 2 locations on frame and 2 locations on spindle. This controls both toe in and caster.

Figure 8 Data Input Screen for IRS Rear Suspension Type

Suspension Analyzer v1.1 Performance Trends [IRS Temp]
 File Edit Graphs Reports Vehicle Specs Adjust Optimize Zoom Animate Preferences Help

Front View Side View Top View No View Dynamic Squal Roll

This is a view from the rear of car (right side of screen is actually right side of car).
 Gain based on 1" Dive.

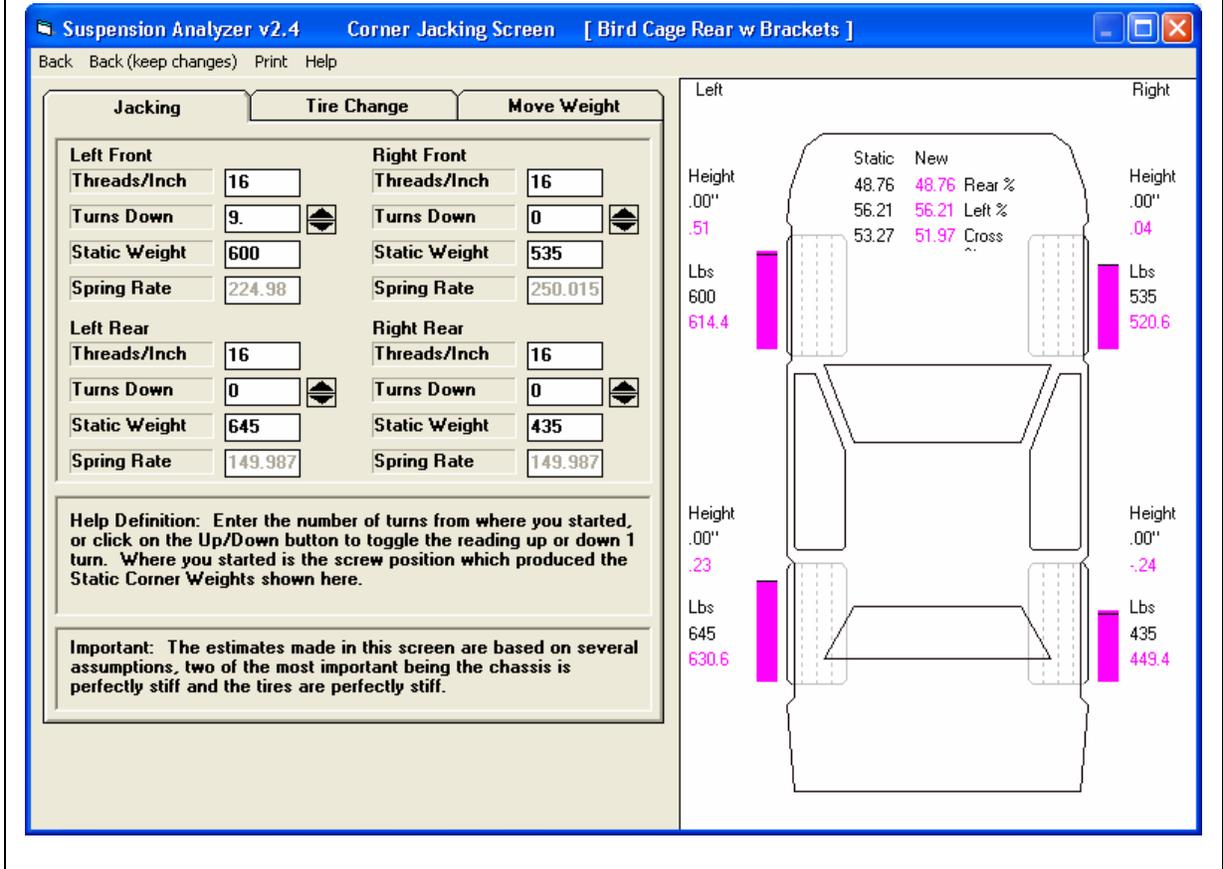
Front Suspension
Rear Suspension
 Refresh

Toe-In Gain: -.18" Roll Center Ht: 6.78 Turn Radius: None Roll Center Right: .00 Toe-In Gain: -.18"
 Camber Gain: -1.47 Caster Gain: -.19 Caster Gain: -.19 Camber Gain: -1.47

Suspension Data							
Location	Type	Lt Out (X)	Lt Height (Y)	Lt Depth (Z)	Rt Out (X)	Rt Height (Y)	Rt Depth (Z)
Upper Arm Pivot on Spindle	Input	24	19.5	1	24	19.5	1
Upper Arm Pivot on Frame	Input	16	17.5	3	16	17.5	3
Lower H Arm on Spindle, Front	Input	25	6	-4	25	6	-4
Lower H Arm on Frame, Front	Input	13	7	-6	13	7	-6
Lower H Arm on Frame, Rear	Input	14	7.5	5	14	7.5	5
Lower H Arm on Spindle, Rear	Input	24	5.5	3	24	5.5	3

The Virtual Scales feature shown in Figure 9 lets you change certain vehicle specs and see the effect on Corner Weights.

Figure 9 Virtual Scales



FLLD (Front Lateral Load Distribution)

When a car makes a turn, weight is transferred from the inside tires to the outside tires. However, how this weight transfer is split between the front and rear has a huge impact on the feel and handling of the car. If more weight transfer occurs on the front of the car, the outside front tire is being “overworked” more than the rear outside tire, causing less cornering traction at the front. This is more likely to produce understeer or a push. Very simplistically, if the Front Lateral Load Distribution is 50%, that means the weight transfer split between front and rear is the same, and that should produce neutral handling. The book “Race Car Vehicle Dynamics” by Milliken and Milliken (with assistance by Terry Satchell) discusses this concept in detail. This concept is similar to the idea of balancing the front and rear roll angles presented in recent magazine articles.

Figure A 6.2 shows the program displaying the FLLD for the current vehicle (currently 44%, which would tend to have Moderate Oversteer) during the transition between releasing the brakes and going to the throttle, at the apex of the turn (transition between braking and power). During braking and under acceleration, the weight transfer is much more complicated, and the FLLD concept can not be as easily applied.

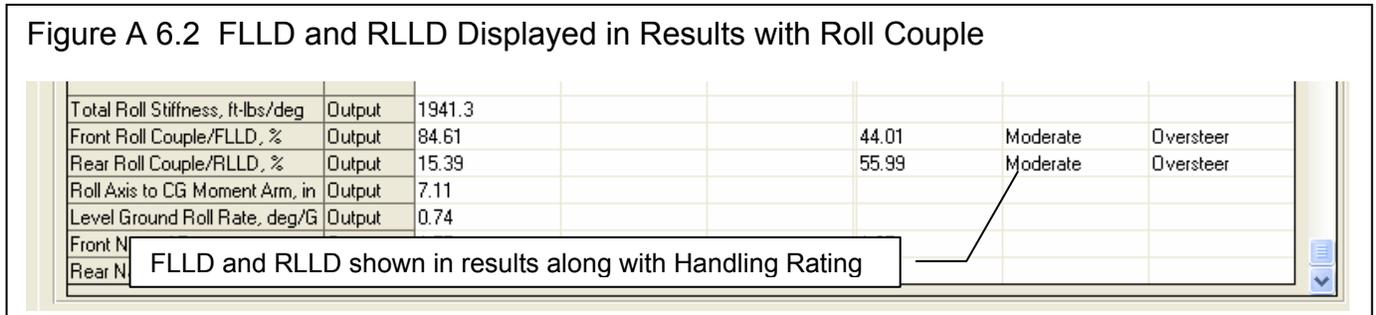


Figure A6.3 is displayed if you click on the “Find” button shown in Figure A6.2. This “Find FLLD” screen lets you find a certain Front Lateral Load Distribution (FLLD), which can be a good indication of how the car will handle at the apex or transition of the turn (no power, no braking).

Pick the 'Adjust' factor to tell the program what vehicle component(s) you want to adjust. Enter your desired 'For This FLLD', then click on the 'Find Now' button. For perfect theoretical 'Balance', the FLLD should be 50%. However, from experience, Milliken suggests a target 'starting point' FLLD value of 5 percentage points higher than the percent weight on the front tires ($100\% - \text{Rear Wt } \% = \text{Front Wt } \%$). By default, the program will load in this value, but you can change it to anything else you want. Higher FLLDs tend to make the car tighter, with more understeer. Lower FLLDs tend to make the car looser, with more oversteer.

There are several ways to obtain a certain Front Lateral Load Distribution percentage. To reduce the possibility of using very strange settings, the program will calculate the average front and rear natural frequencies for the springs. If these frequencies are significantly different than those typically used, the program will warn you. Typically, the front natural frequency will be in the range of 1.4 to 2.0 and the rear will be .1 to .5 points lower than the front.

For many vehicle combinations, the program can not find settings to match your requirements. Many times this is due to the Front or especially the Rear roll centers

Figure A 6.3 Find Front Lateral Load Distribution by Clicking on Optimize

3) Click here to have program find new settings.

1) Pick what to Adjust.

2) Select the FLLD you want. The program will default to a typical value based on your car's weight distribution.

4) Click here to have program save these new settings.

Find Front Lat Load Dist

Current Front Lat Load Dist: 56.8

Current Rear Springs: 150 / 180

Current Nat Freq, F/R: 1.75 / 1.68

New Front Lat Load Dist: 55.0

New Rear Springs: 196.4 / 235.7

New Nat Freq, F/R: 1.75 / 1.92

Find Now

Options

Adjust: Rear Springs

For This FLLD: 55.0

This change tends to make the car slightly looser.

Note:
The new settings you find using this feature may NOT be best your driving style and could be UNSAFE. Click on Help for more info.

For this vehicle's Front Wt % of 50.0%, 55.0% (5% higher) would be a suggested setting.

OK/Keep Help Cancel Print

being too high. High roll centers transfer more weight laterally through the suspension linkages and less through the springs, making the springs and roll bar have less effect on this tuning factor. You may then want to have the program adjust the Rear Roll Center to find the FLLD you desire. After you adjust the Rear Roll Center and keep this change (click on OK/Keep), then you can go back into this screen and try adjusting springs and/or roll bar and they are likely to have more affect.

The new settings you find using this feature **MAY NOT BE THE BEST AND COULD BE UNSAFE.**
USE YOUR JUDGEMENT when making adjustments based on this concept.

To Obtain This Result...

Choose what result you want to obtain, like to maintain a certain Roll Center Location (Left or Right) or Roll Center Height, Bump Steer (which is Toe In/Out), or Camber. If Roll Center Height or L/R are not mentioned, then you are asking both to be kept stable (maintained).

Some options let you try to match a 'Specified' Roll Center Vertical or Horizontal location. If you select this option, then the Vertical and Horizontal data entry boxes become enabled for you to enter values. Note: To specify a Horizontal Location LEFT of center, enter a negative (-) number. Roll Center Height typically has a larger impact on handling than location Left or Right, so some of these options let you concentrate, say, 4 times more on maintaining height constant than horizontal motion. This means that a 1 inch change in height will be considered as important as a 4 inch horizontal change.

See Section 2.6, page 47 in this manual for more explanation of this Optimize Screen.

See **Appendix 6, New Features in v2.0** and **Appendix 7, New Features in v2.4** to see all the new types of rear suspension geometries which can be simulated in the Full Vehicle version.

Torque Tube Live Axle	5 Link Independent (like C4 Corvette)
Torque Arm Live Axle	Trailing Arm and Semi Trailing Arm
Leaf Spring Live Axle	Decoupled (bird cage) Live Axle
	H Arm Independent (like IRS Thunderbirds and Cobra Mustangs)