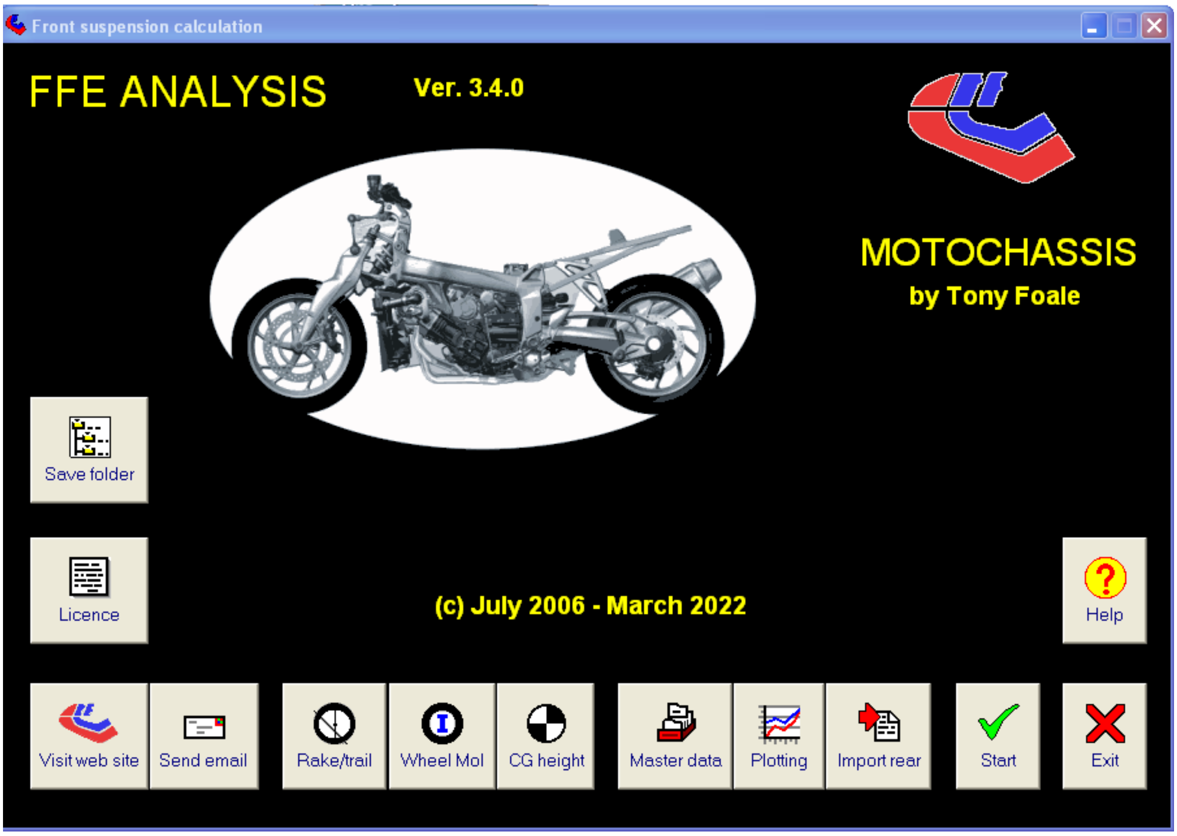


Software User's Manual

Version 3.4.0

Tony Foale Designs © 2022

Last revision 26/08/2022

Contents

Introduction

I know of no other software available for analysing various parameters of interest, such as anti-dive etc. for that class of motorcycle front suspension controlled by some form of swing-arm and/or pivoted links. The oft used term “Hub-centre steering” doesn’t cover the whole range of these alternative designs and I use the all inclusive term of FFE or “Funny Front Ends” , hence the name on this software.

I frequently needed to do such calculations and developed this software to fill the gap initially for my own work. However, as word got around of its existence I received a number of requests from interested people to buy copies of the software. To my surprise although there was a small market it was large enough to warrant developing the software as a marketable item.

Even though interest in these types of front suspension is still limited, I have spent some time to make this software more useful and have added various features, as well as preparing this user’s manual. Versions 1.00 to 2.xx only considered the geometric effects of the linkages without concern for the effects of suspension springing. Version 3.xx has the added ability to add springing to either the top or bottom links directly or through a simple rocker and link system. So now in addition to generating dive data in terms of a percentage anti-dive, it will calculate the actual dive and other suspension related effects in terms of suspension travel itself. To further add to the usefulness it is now possible to import rear suspension characteristics from my “Whole bike” software. These additions to the software have increased its usefulness by a large margin.

I am always receptive to ideas for improvement and reports of any problems. Any such comments can be emailed to *info@motochassis.com* .

What will it do?

The software will analyze most forms of what might be called link suspension. It will put numbers to various characteristics. In the early versions these included: anti-dive percentage, rake angle variation, trail variation and wheel trajectory. Version 3 adds considerably to that list with: Wheelbase variation, force centres, link angles, shock displacement, wheel/shock forces, wheel rate, velocity/motion ratio and brake dive under various degrees of braking.

It will graph all of these parameters against suspension movement, or in the case of brake dive, against braking deceleration.

Designs which fit into this category include, hub centre steered designs such as Difazio, Bimota, Vyrus etc. and other FFE designs such as Hossack (with or without suspended head stock), BMW Duolever, many of the Elf designs, Foale/Parker/Yamaha GTS and many more. Although not designed with them in mind it will also handle head stock mounted forks like girders and leading/trailing link.

What it will not do.

It will not handle any system with sliding elements such as the Saxon/BMW telelever nor telescopics.

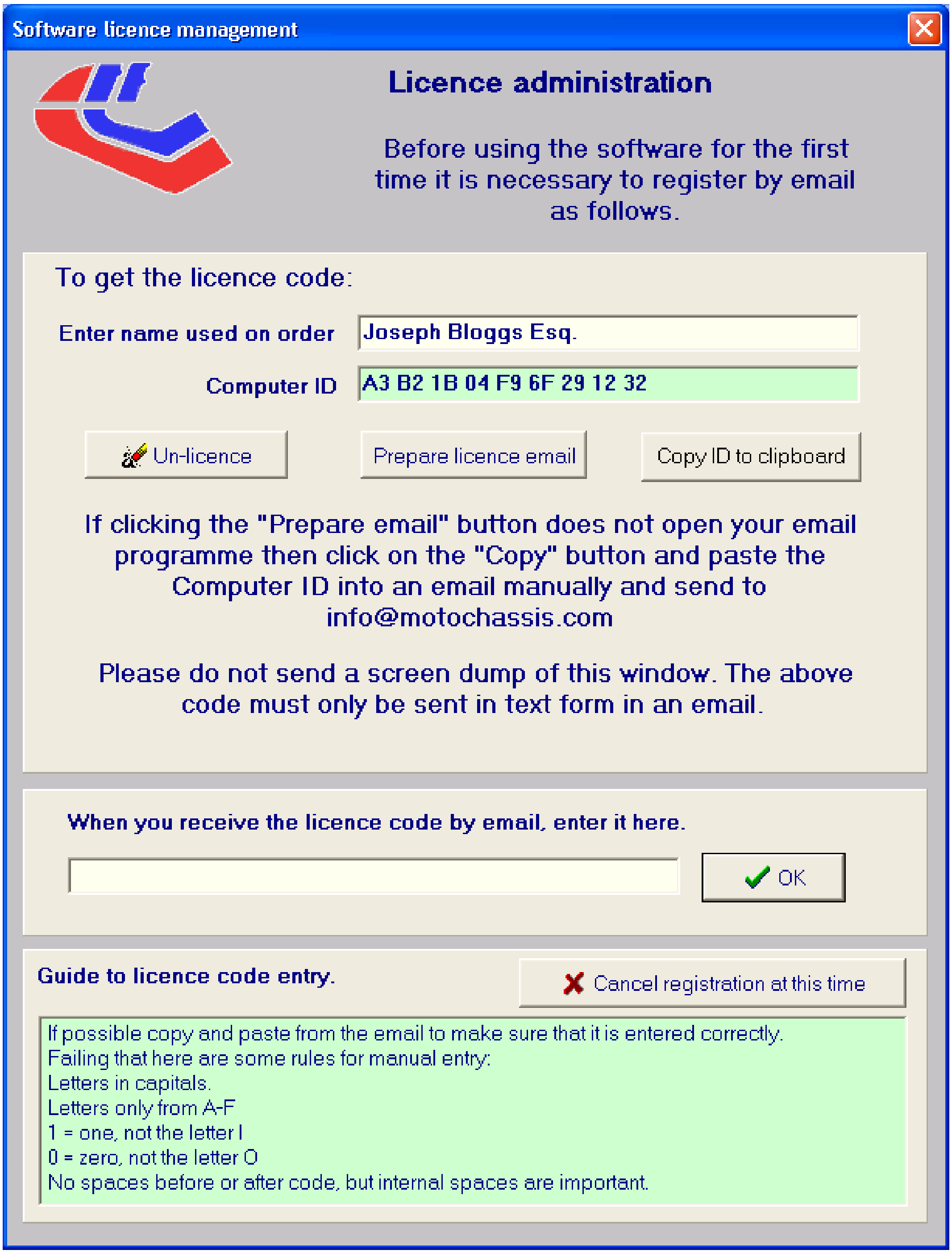
Tony Foale.

August 2022

First time use – licence management.

When the software is started for the first time, you will be presented with the following licence screen. Fill in your name used for purchase and click on the "***Prepare registration email***" button. This will prepare an email in your default email client. If your email client does not respond then click on "***Copy ID to Clipboard"*** and then paste the ID manually into an email and send to *info@motochassis.com* If you do not use the computer for email then you can make a note of the customer code and send an email manually from another computer to *info@motochassis.com* You can then close the software.

Is important that the ID is in text form in the email, please do not send a screen print of this window.

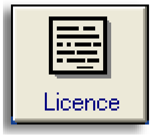


A licence code will be emailed back to you. When you receive this code, restart the software and enter the code where indicated. The software will then shut down and then function fully when restarted.

It is important that you only use the licence code on the same computer that showed the emailed "Computer ID". Both of these codes are unique to each individual computer and will not work on another machine.

Procedure to transfer licence to another computer.

If you wish to change the computer on which you use the software, then firstly enter the above licence screen by clicking the



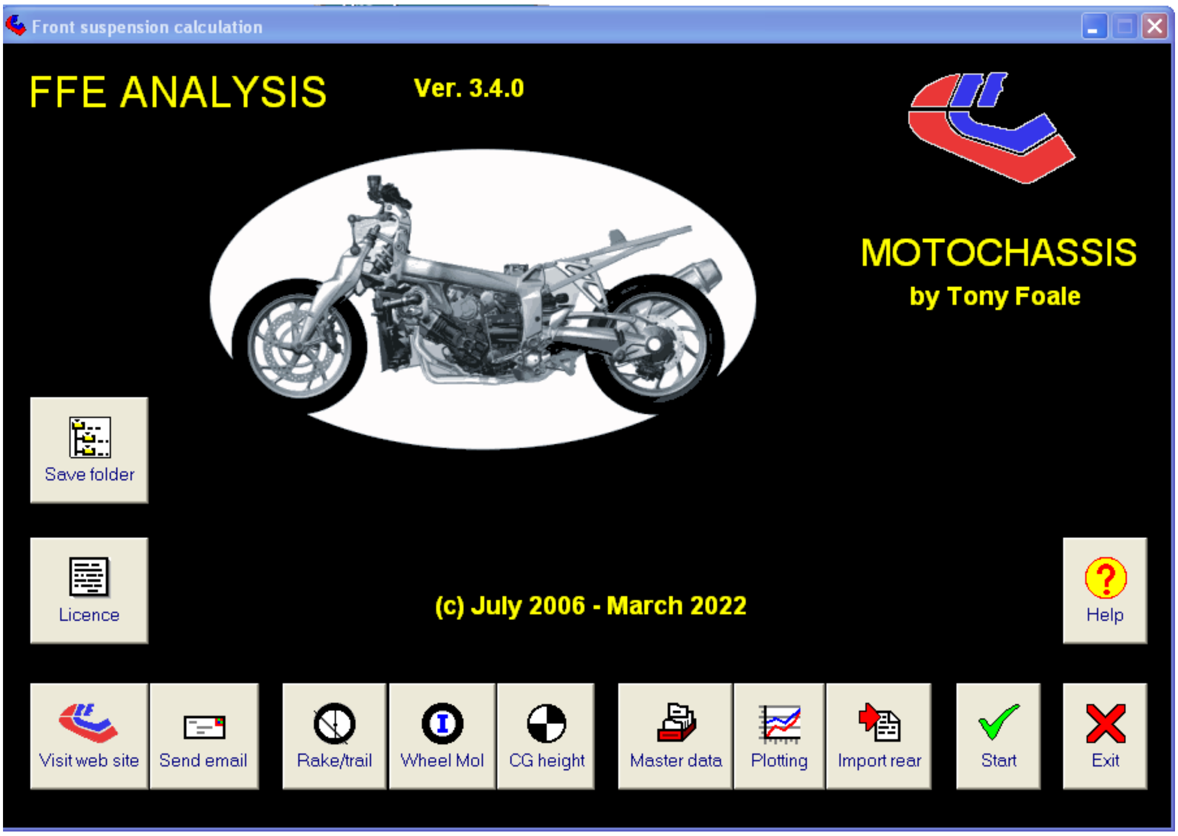
button on the opening window. (On the original computer.)

Then click the

button. Make a note of the un-licence code that appears. Install the software on the new computer and email the customer number for that machine with the un-licence code from the first.

Principal screen

From the opening screen select the required action according to the function of each button.



Button functions (see the Appendix near the end of this document for full details)

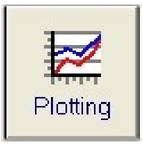
The following three open generally helpful tools, but do not have direct influence on the main calculations.

Evaluates the missing parameter in a set of four relating to steering geometry. Rake angle, wheel size, offset and trail are the four parameters. Enter any three of them and the fourth will be calculated.

Calculator for the moments of inertia of wheels and tyres. There are two different methods included.

Shows one way to measure CG height and does the necessary calculations.

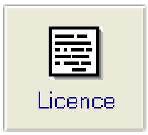
Centre for management of saved project data. Up to ten cases can be saved in the same project file.



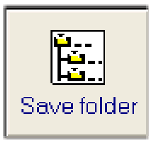
A plotting module which graphs up to ten examples of a selected parameter. This is very useful for comparing the results of different design iterations.

Imports rear suspension data from the separate "Whole bike" software. This modifies the results of the dive calculations due to the effect of the rear on the CG height. Front dive and rear lift are plotted together allowing instant viewing of front and rear shock topping or bottoming out.

This opens the main form for the entry and analysis of the front suspension parameters.



Takes you to the licence management screen as described previously in the section on first time running. Use this also when you wish to transfer the licence to another computer.

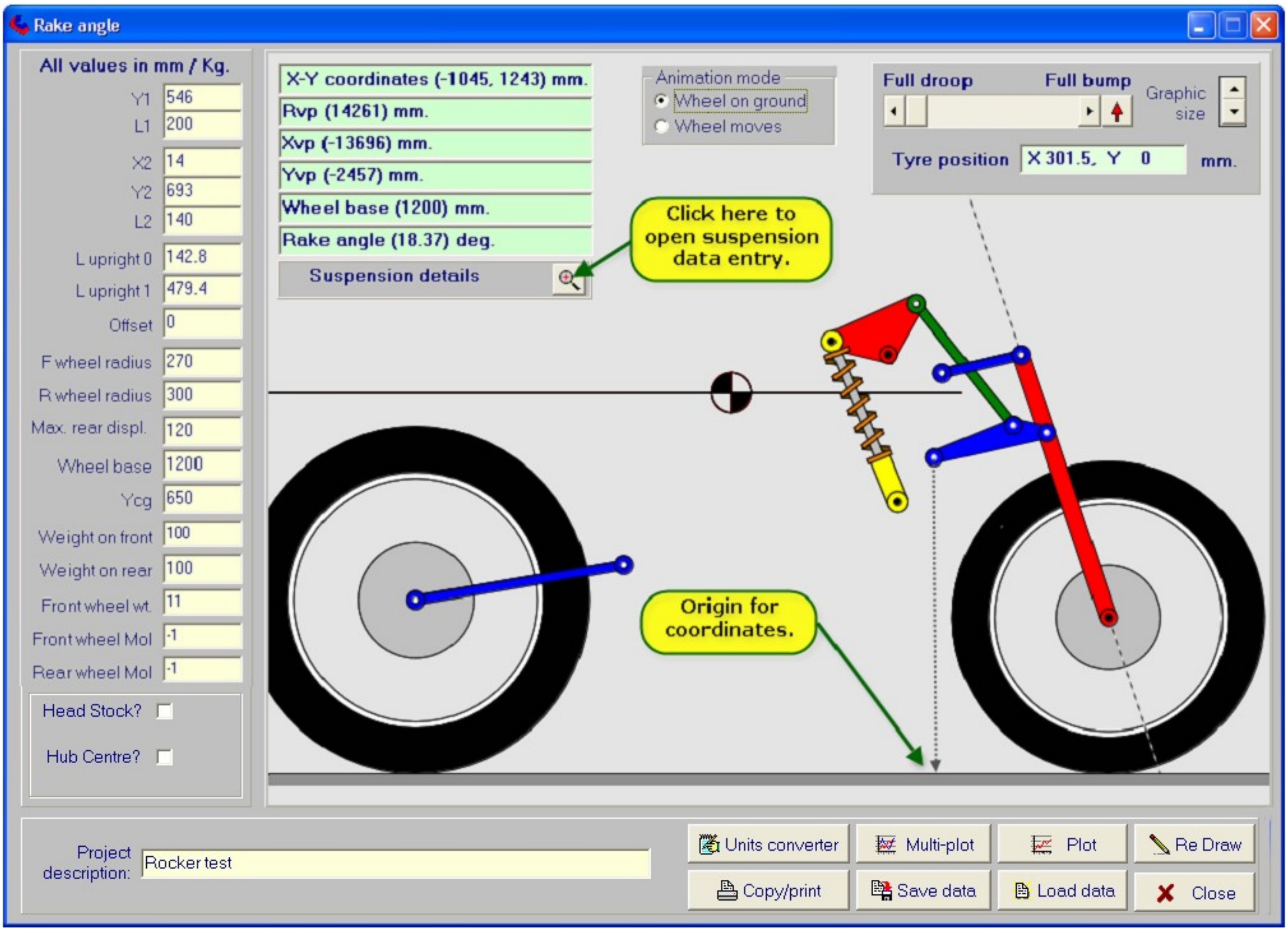


Allows you to select the base directory where you want to save files.

Updates to this and other software will be announced on our web site, so visit from time to time. We welcome feedback and suggestions about this programme and they can be sent by email. *info@motochassis.com*

Description of main FFE analysis features

Main working form.



This screen is divided into four main areas:

1. Miscellaneous data entry on the left.
2. Control buttons at the bottom.
3. Graphic area showing a sketch of the front suspension system as defined by the data.
4. Suspension data shown over the graphic, minimized in the above illustration. (See below)

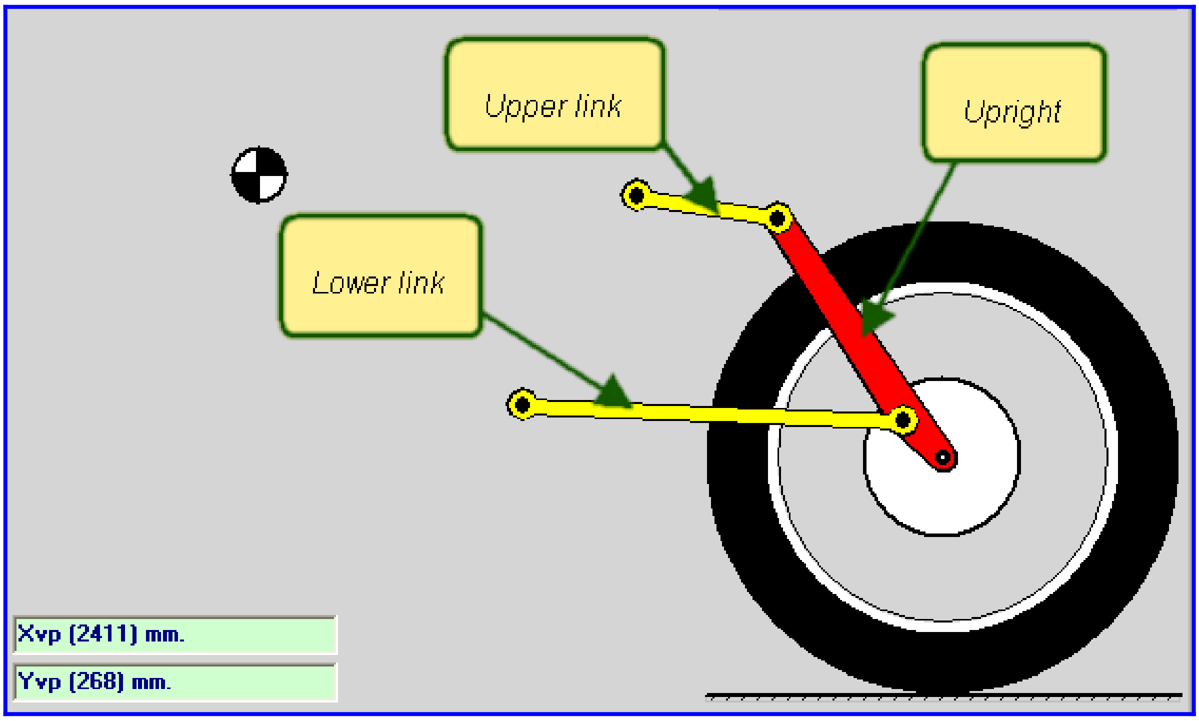
Miscellaneous data entry area

All coordinates are to be determined with both front and rear suspensions fully extended with the wheels just touching the ground.

The origin of the coordinate system, used to specify the location of the frame mountings of the two links, is at ground level directly under the frame mounting point of the lower link (see above illustration). Therefore, the “X” coordinate of the lower link pivot is 0 and does not need to be specified. All dimensions are in mm. Positive is to the right and upward.

Bottom link is defined as link 1, **X1** is 0 (by definition) **Y1** is height of pivot above the ground. **L1** is the link length.

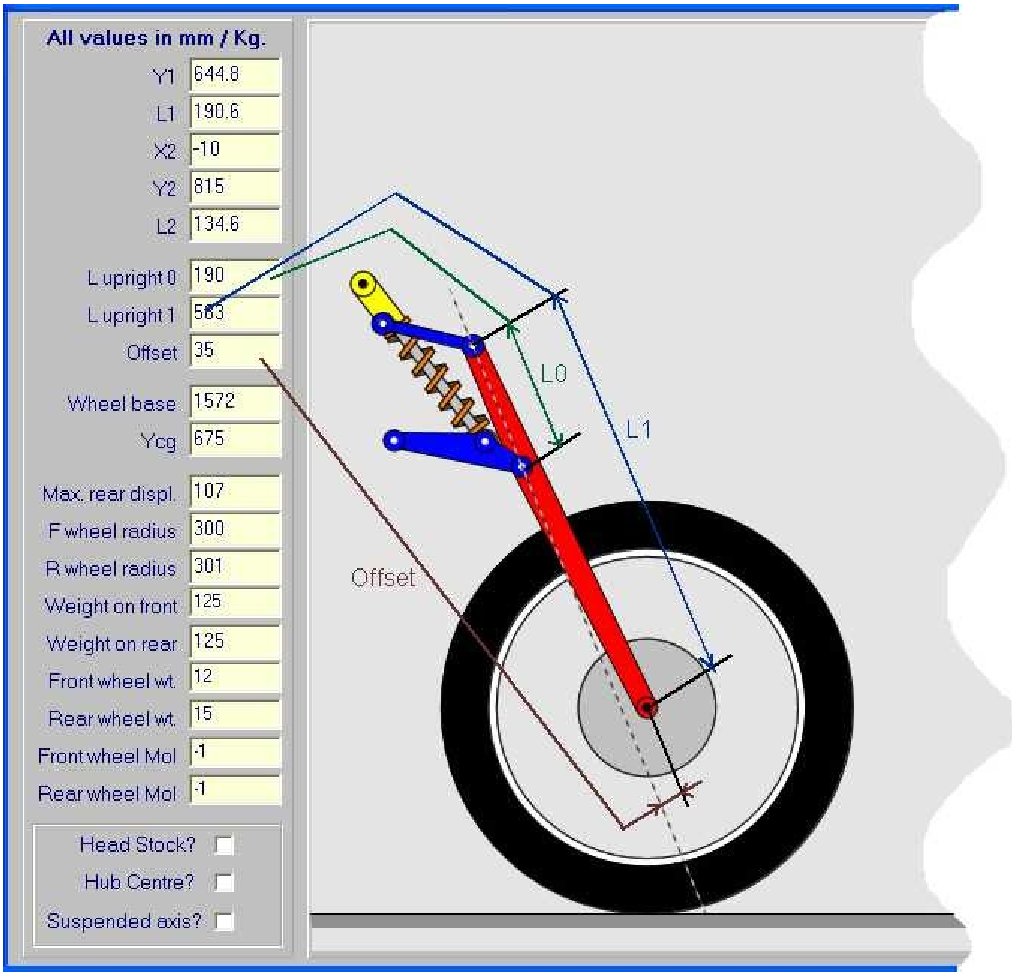
X2, Y2, and L2 have similar meanings for the upper link **as X1, Y1 and L1** have for the lower link.



L upright 0 is the upright length from link 1 connection to link 2 connection

L upright 1 is the upright length from link 2 connection to the axle, measured as shown in the sketch below, and may be greater or less than L upright 0.

Offset is the normal offset of the axle from the steering axis, as defined by a line through the link pivots on the upright, shown in following sketch.



F wheel radius & **R wheel radius** are the rolling radii of the front and rear tyre respectively.

Max. rear displ. is the maximum rear wheel movement. Entered automatically when using imported rear data.

Wheelbase is the horizontal distance between front and rear axles.

Ycg is the loaded CG height above ground level. The CG height is used in the calculation of the anti-dive percentage. If you have an error in the Ycg input then the values of the percentage will be out but the trend of the variation will be similar.

Weight on front and **Weight on rear** are the loads supported by each tyre with the bike loaded.

Front wheel wt. is the weight of the front wheel, tyre and brakes, etc.

Front wheel MoI and **Rear wheel MoI** are the polar moments of the front and rear wheels, tyres and disks. If this information is unknown then use a value of –1 will force the software to use default values which are quite close enough for most practical purposes. A MoI calculator is built into the software and is described elsewhere in this manual.

Head stock forks

Some types of head stock mounted forks like the older Girders and Leading Link (LL) can be analyzed with this software but in those cases the steering axis is not defined by the line through the forward link joints, but by the axis of the headstock itself. In these cases tick the '**Head Stock'** option and enter the values of the head stock rake angle and the offset of the axle from that axis. This will ensure the proper calculation of the rake and trail variation with suspension movement. Note that in these cases the offset of the upright as described earlier is not the same as the offset from the steering axis. In the case of link forks the upright offset will generally be zero, but with girders it will likely be non-zero. Link forks do not generally have a part directly like the upright of girders or other types of link based front end. Instead the axle is generally fixed to the end of the link itself but for the purposes of analysing the anti-dive characteristics we can treat the caliper bracket or drum brake back plate as the upright. Then **L upright 0 = L upright 1** and **offset of the upright = 0**. An example data set is shown later. For trailing link forks enter a negative value for the value of L1, the main link. The negative value signals the software that both links are trailing.

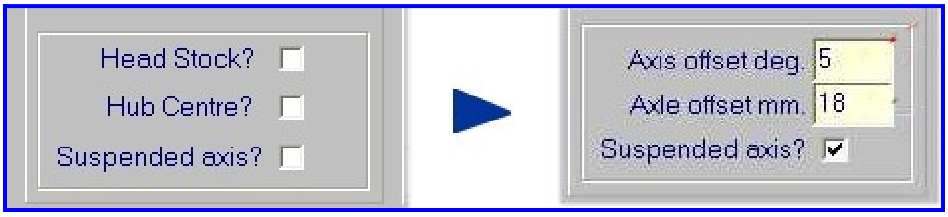
Hub Centre

Hub Centre systems have the lower steering pivot contained within the wheel hub. This is usually coincident with the lower link front pivot (from a side view) but there is a design class where the lower link front pivot does not define the steering axis. (Google on Romanelli.) Tick this box for those cases, although it matters not whether this is ticked or not for those systems which have the steering axis coincident with the lower link pivot.

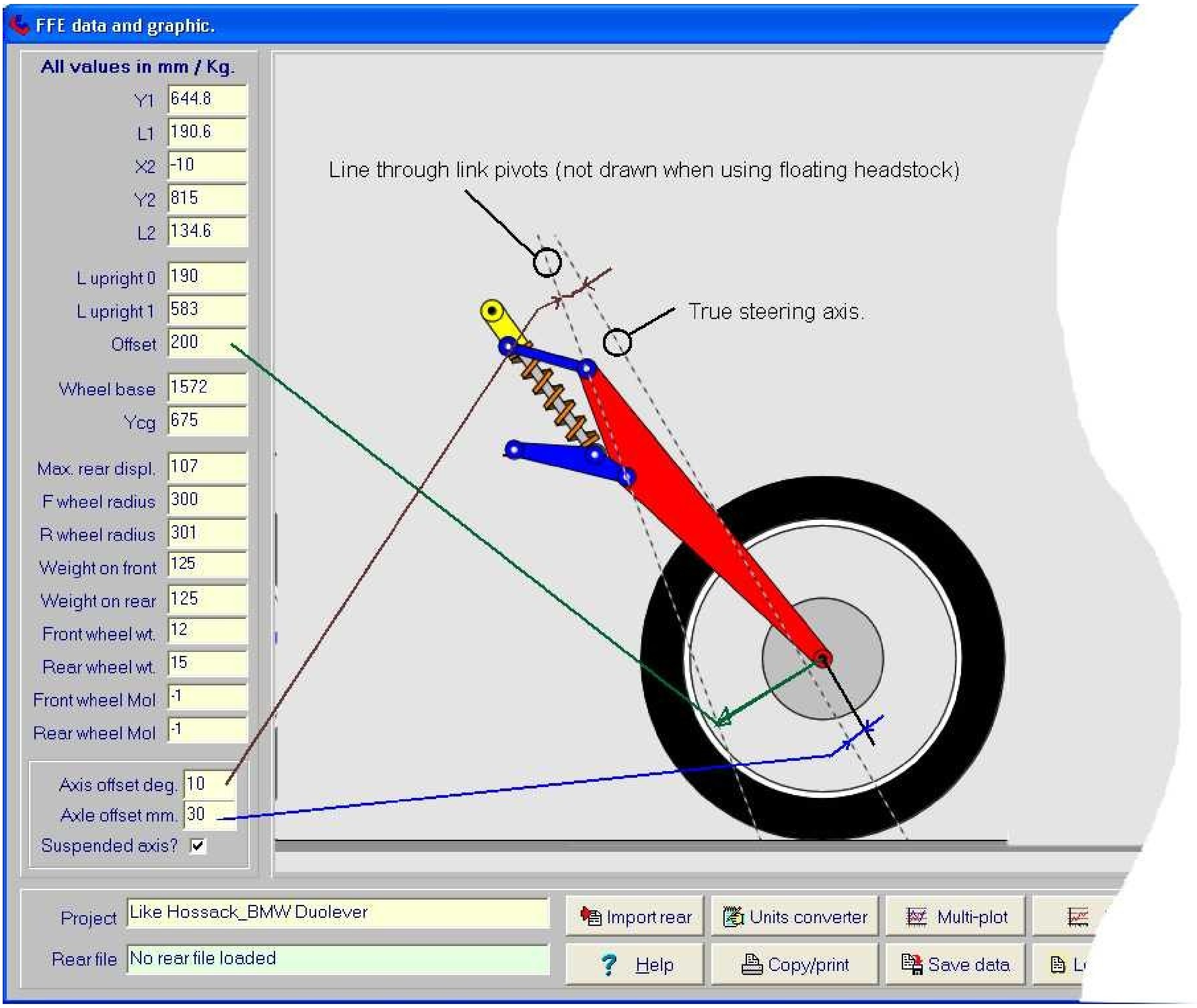
Suspended axis

This option is for those designs, generally the Hossack style, which use a floating or suspended headstock. This design feature permits the use of low friction rolling bearing in place the higher friction ball joints commonly used. It also permits the use of a steering axis and rake angles different from that normally defined by the axis through the front link pivots, giving an extra design option for tailoring overall characteristics. The significance of the additional parameters is shown in the following illustrations. The true steering axis is the sum of the angle through the forward link pivots and the "Axis offset deg". The value of "Axis offset deg" can be positive, negative or zero for a parallel headstock offset.

Note: After making changes to any data, click on the **ReDraw** button to update the graphic.



This option box (left) allows selection of modifications to the basic design. These options are mutually exclusive and selection of any one disables the other two. When either the "Head Stock" or "Suspended axis" is chosen, two additional data entry boxes will be displayed, as shown to the right.

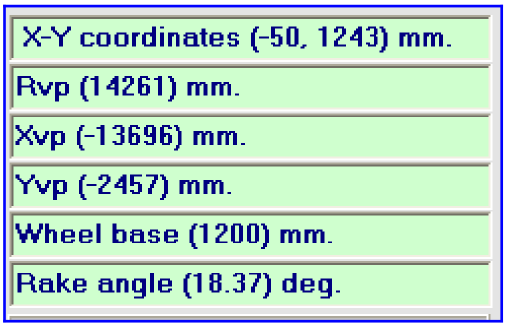


Showing the significance of the extra parameters when using a suspended headstock. The trail values are based on the true steering axis and the "Axle offset mm" value. The upright "Offset" only defines the geometry of the upright and plays no direct part in determining trail in the case of a suspended headstock. The true steering axis is the sum of the angle through the forward link pivots and the "Axis offset deg". The value of "Axis offset deg" can be positive, negative or zero for a parallel headstock offset.

Graphics area

This shows an animation of the front suspension system as defined by the entered data. There are controls for studying the movement of the suspension through its specified range. After changing data, click the Re-draw button to refresh the graphic.

There is an information panel (shown below) within the graphics area which shows selected parameters as the suspension is moved through its range.



X_Y coordinates show the cursor position relative to the origin.

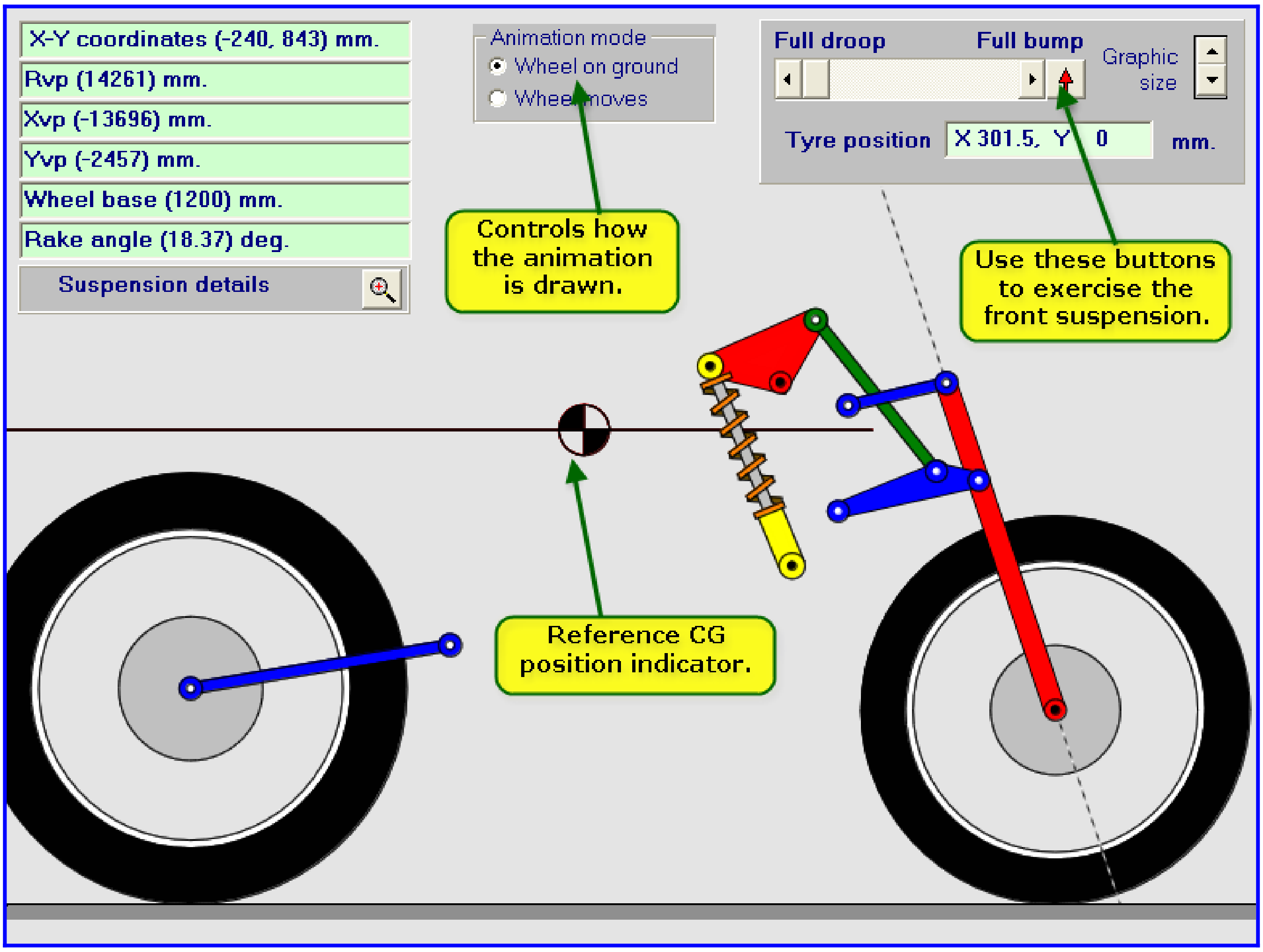
Rvp is the radius to the virtual pivot or force centre.

Xvp & Yvp are the coordinates of the virtual pivot or force centre.

Wheelbase is the wheelbase in that wheel position.

Rake angle is the angle of the steering axis from the vertical.

These values change as the wheel is moved through its range.



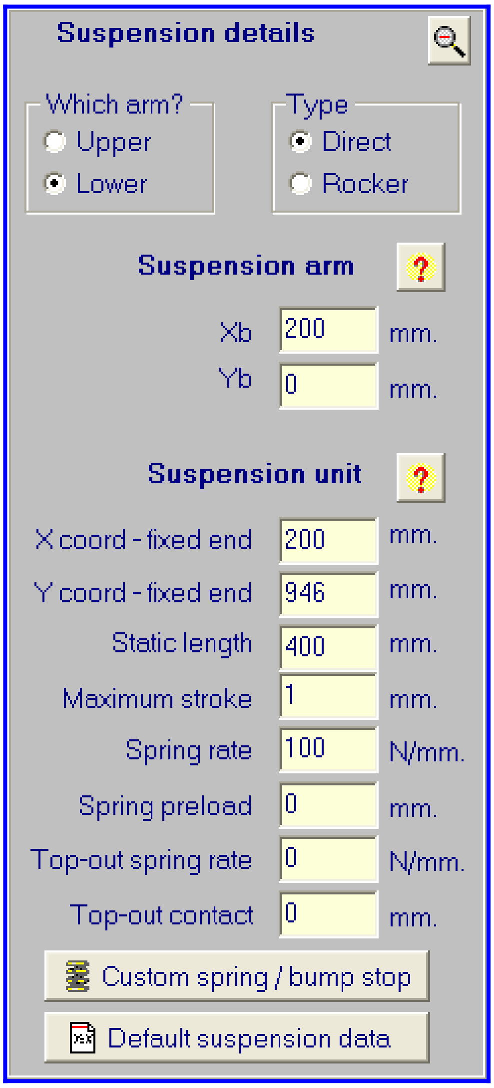
The coordinates shown as **Tyre position** in the top right box are those of the tyre contact point directly under the front axle. There are always tolerances on any measured data and it is most likely that when the **Animation mode** is set to **Wheel moves** there will a non-zero value for the Y coordinate and if the error is enough it will be obvious from the graphic as well. If this error is only a few mm. then it probably means that your data entry has been done correctly but measurement tolerances are showing their effect. If the tyre to ground level error is larger then it indicates either that a mistake entering data has been made or that at least one piece of data needs to be measured more accurately. If your data has come directly from a CAD drawing then it should be sufficiently accurate and the Y value will show zero.

The height of the CG line will be drawn lower than the user specified height. This is not an error and is due to rotary inertia effects of the wheels.

Suspension data entry

Click the expand button on 

to gain access to the suspension data entry as follows.



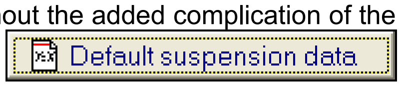
This is the basic suspension data entry box. When the **Rocker** selection is made an additional box is opened for the rocker and link data.

Which arm? – specify whether the suspension is connected to the upper or lower arm.

Type – choose **Direct** if the shock is mounted directly to the arm/link with the other end fixed to the chassis. Otherwise if the shock is connected through a simple rocker and link system then choose **Rocker.**

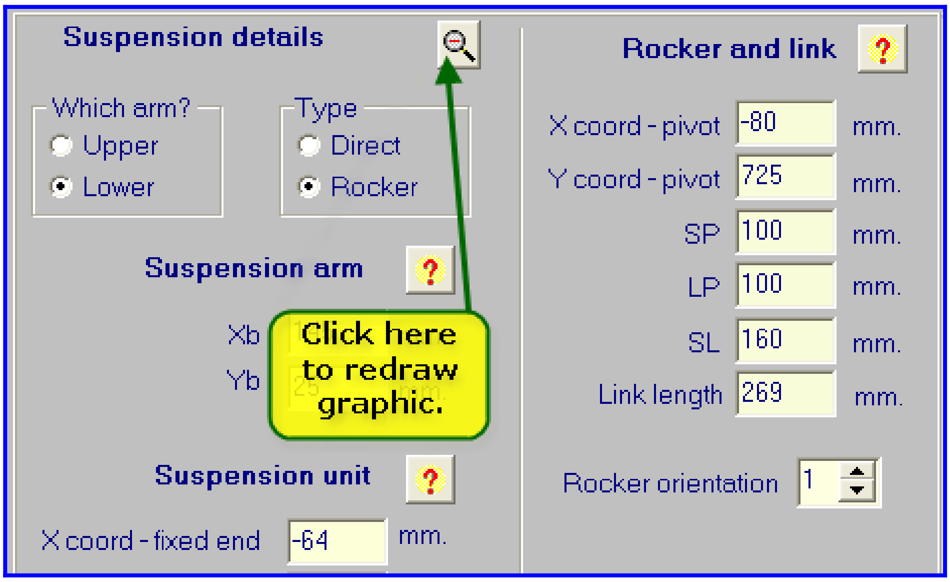
Descriptions of the remaining data are available directly within the software by clicking the ? help buttons.

Important note:

When entering data for a new design for the first time there may be some unforeseen geometric inconsistencies which might only show up as the system is moved through its range of suspension movement. For that reason it can be helpful to limit suspension travel in order to concentrate on checking out the basic link geometry without the added complication of the suspension details. Clicking on the 

button will automatically load basic suspension parameters with 1 mm of shock stroke. A shock will be mounted to the front of the lower arm with a top shock mounting vertically above the lower one at a height (Y-coordinate) such that the tyre contact point will be close to ground level. You can then manually adjust the **Y-coord – fixed end** value to adjust the wheel position such that the contact point is on the ground. The **Animation mode** must be set to **Wheel moves** to see this. When this operation is correct you can increase the **Maximum stroke** value to give the desired range of wheel displacement. Exercising the suspension as described in the previous graphic will then show if there are any geometric problems with the overall layout.

You are now ready to enter your actual shock parameters.

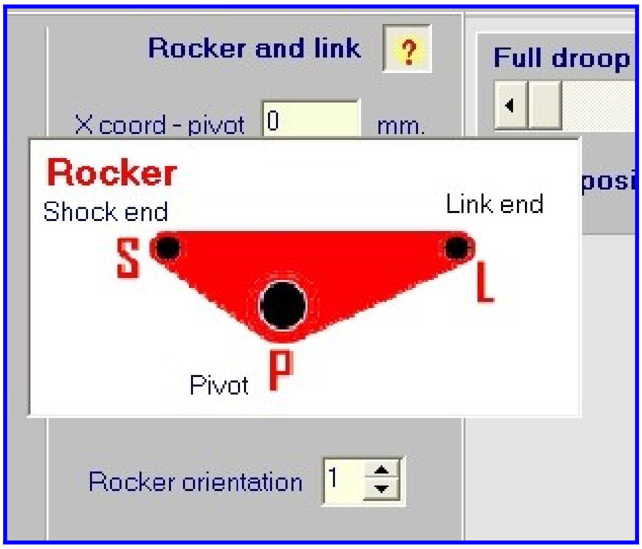


When **Rocker** is selected as the **Type** then an additional data entry panel will display as shown. The help button will display the meaning of the rocker data, as shown below.

Note that the dimensions **SP, LP** and **SL** refer to the connections of the rocker and not to the right or left as in the help graphic.

Click on the reduce button to close the data entry panel and redraw the graphic with the specified data.

The significance of the Rocker orientation is explained below.



The rocker fly out help graphic.

Note that the dimensions **SP, LP** and **SL** refer to the connections of the rocker and not to the right or left as in the help graphic.

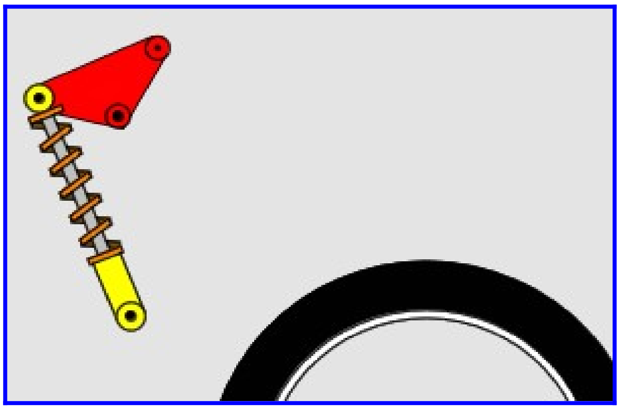
The purpose of the **Rocker orientation** value is described next.

Rocker orientation

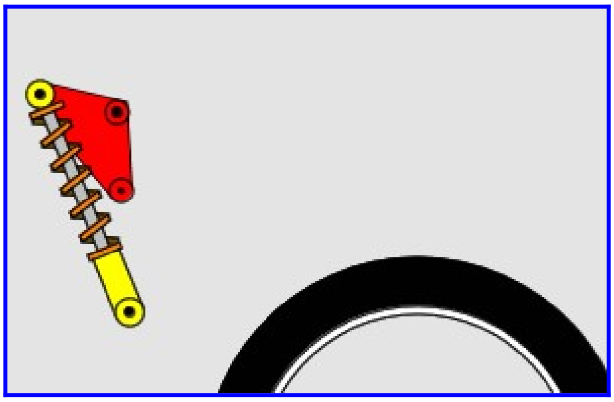
There are four possible orientations of any given rocker design *(It can be flipped horizontally and/or vertically.)* and there is no way that the software can determine with 100% certainty which is the intended one. The user can use the spin control to toggle through to select the desired configuration if the software guesses wrong.

The following illustrations (which appear when the spin control is used) show the four alternative orientations for this particular design. The correct orientation, in this case, is "1" as can be seen by reference to the graphics on the previous page. Some orientations lead to impossible physical layouts. To avoid the inherent problems of trying to draw impossible layouts, the illustrations only show the wheel, rocker and shock. An incorrect orientation is physically equivalent to an assembly error on the bike, although that is usually prevented by mechanical constraints such as different mounting fittings on each end of the rocker.

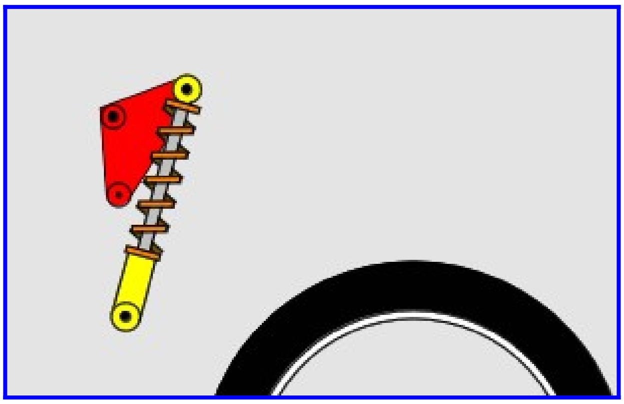
Orientation 1



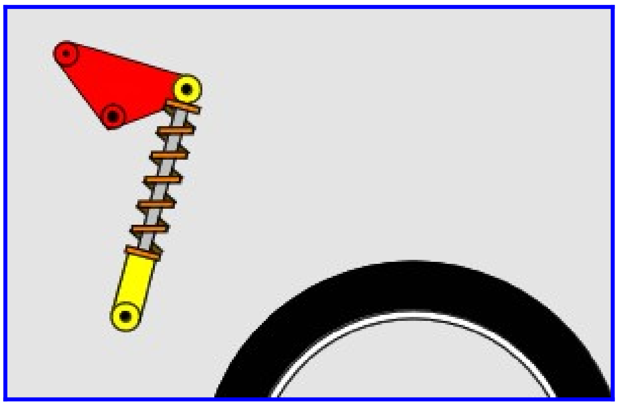
Orientation 2

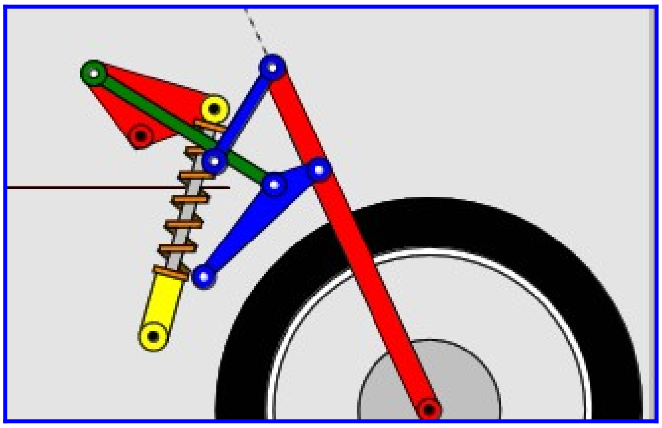


Orientation 3



Orientation 4





To the left we see the effect of choosing an incorrect orientation of the system above. Orientation "4" instead of "1". In this case the rocker is flipped horizontally. Strangely this design reverses the action of the shock. That is, as the wheel is lifted the shock extends rather than compresses.

Also with this design any attempt to use orientations 2 or 3 will result in an error message indicating that it gives impossible geometry.

The user is encouraged to play with this control to get familiar with its effect. It may be advantageous to reduce the graphic size to view the whole system when the data entry box is visible.

Button area

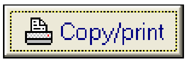
There are several buttons here which either control the calculations or access other functions. All are listed below and described in more detail in the appendix.

Converts between metric and imperial units of measure.

Plots the results of up to ten cases to be directly compared on one graph page.

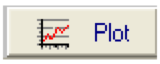
Loads a previously saved data file containing all the dimensions of a saved case.

Calculates the configuration and refreshes the graphic after any data changes.



Presents options to copy, save or print the graphic.

Saves the current configuration data to a file for later recall.



Displays several calculated characteristics throughout the range of suspension movement for the current case. The pre-defined graphs include anti-dive, rake angle, trail, the trajectory of the wheel axle and several more.

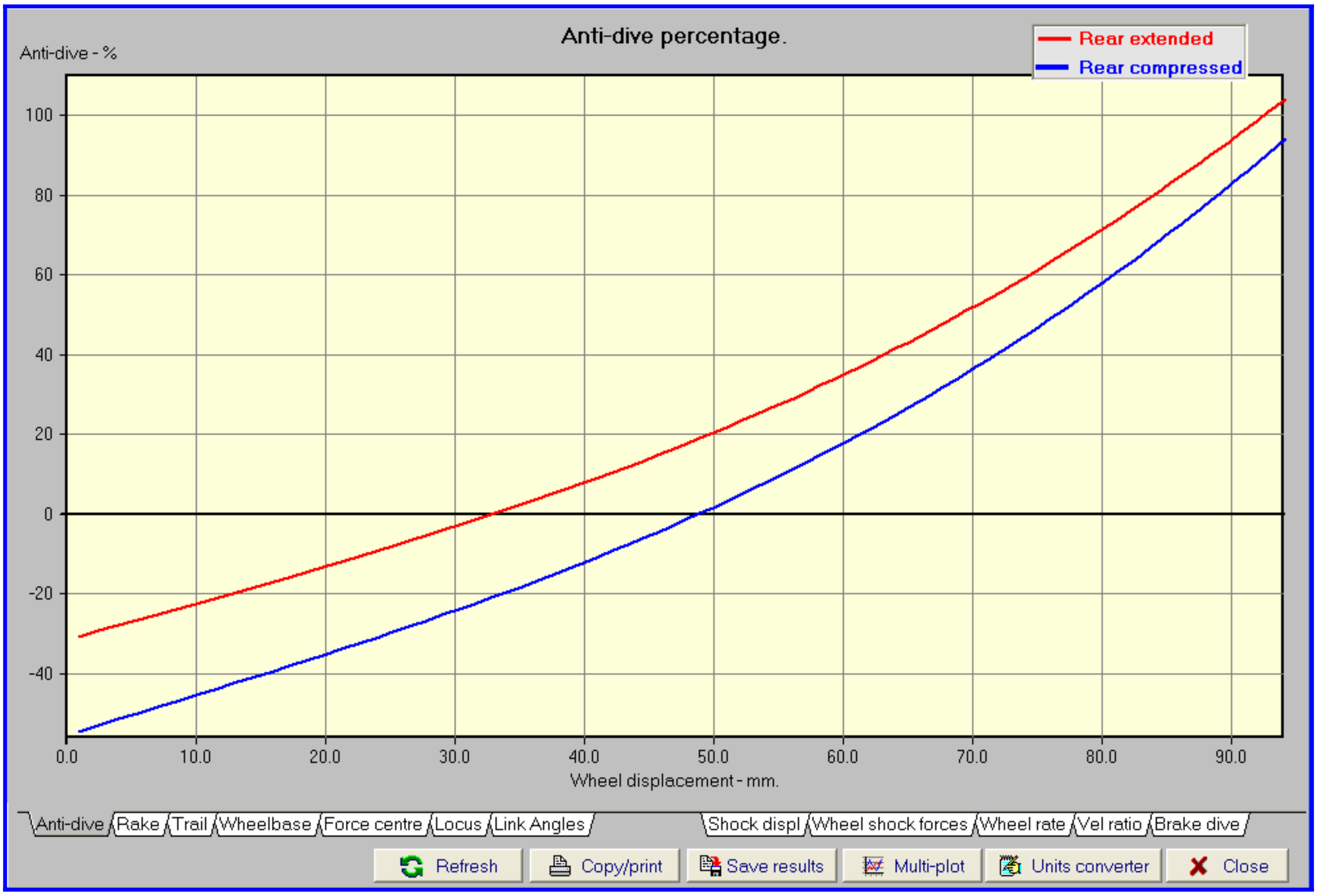
Example results plots

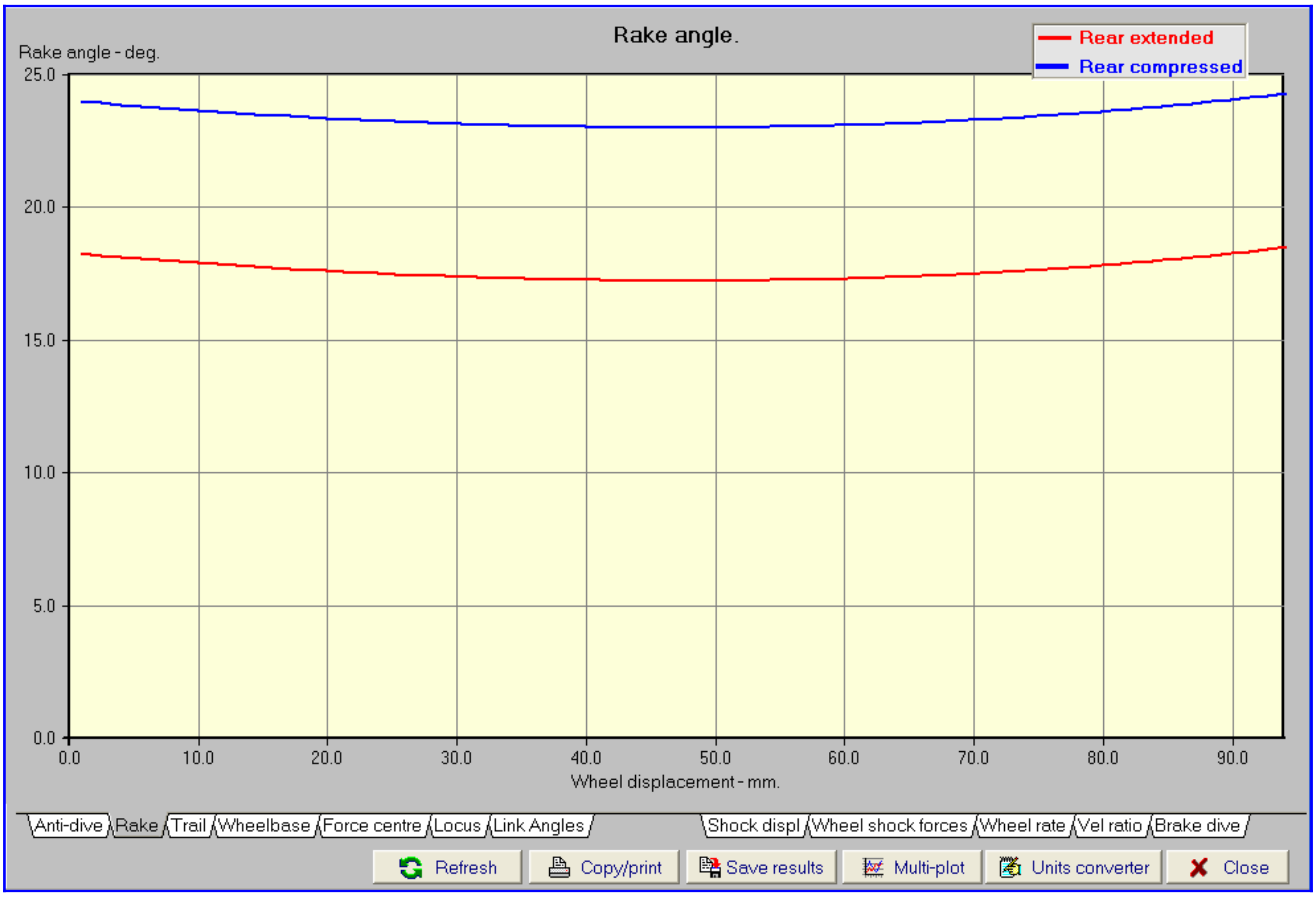
There are several sets of calculated parameters pre-defined and plotted: anti-dive percentage, rake angle, trail and the trajectory of the wheel axle. The first three are plotted for the two extremes of rear wheel position and the area between the two curves defines the range of possible values for a particular parameter. The wheel trajectory plot also shows the wheel path that would occur with telescopic forks at a specified rake angle, this is just for reference.

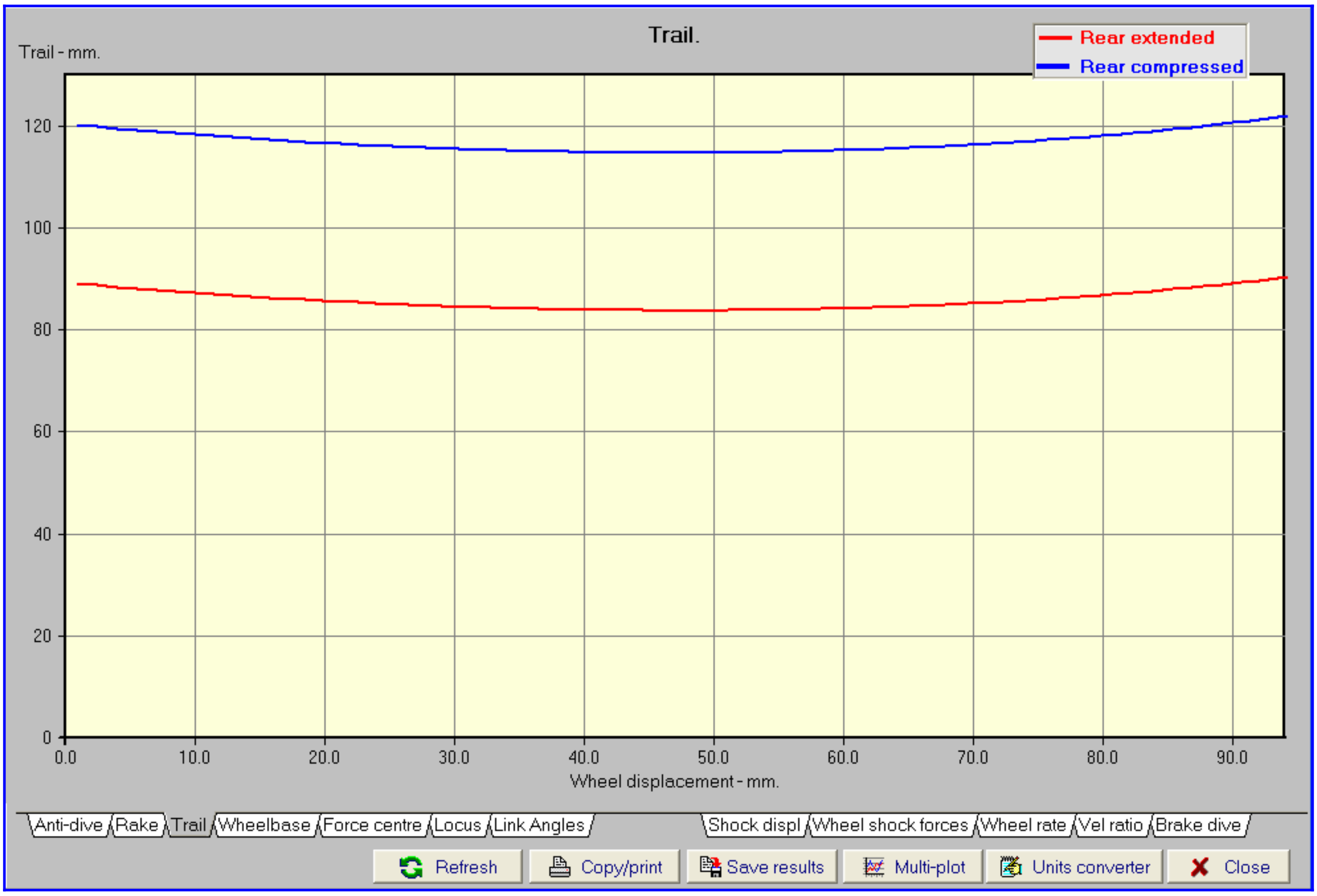
There are some special features available when the mouse pointer passes over a graph area.

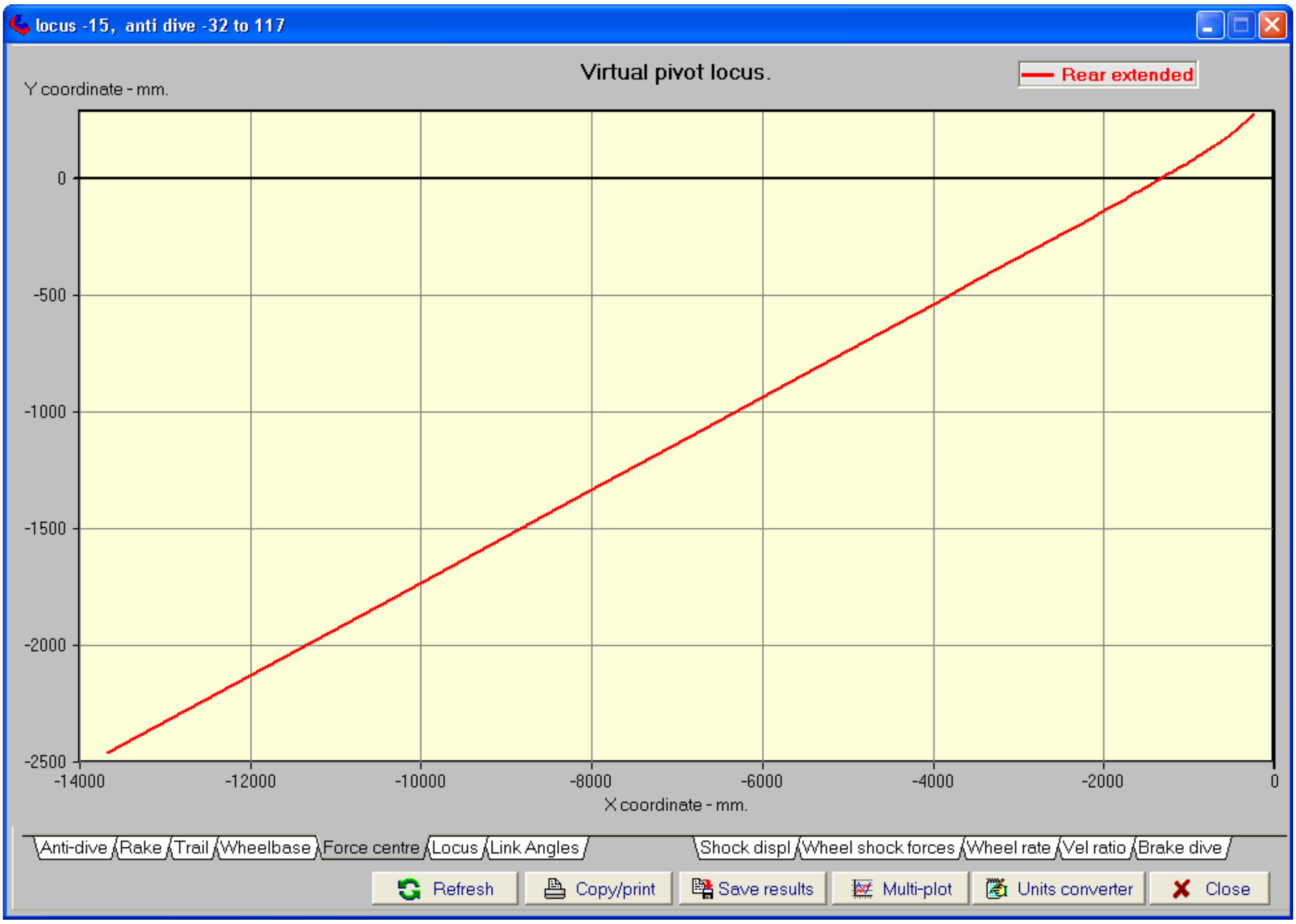
- Cross-hairs appear automatically showing the X-Y values.
- Marking points. To mark a point, just click and release without moving the mouse. This will mark a point on a graph and show the X-Y parameter values.
- Line drawing. To draw a line, click and hold at the start and release at the end. The slope of the line will be calculated and displayed.
- Changing graph pages will remove the marks and lines, as will clicking the **Refresh** button..
- The graph data can be saved in numeric form to a file, which can be later be used in the multi-plotting feature to compare multiple cases.
- The graph window can be saved to the clipboard and subsequently pasted into other software for creating reports etc.

The following are typical results graphs:

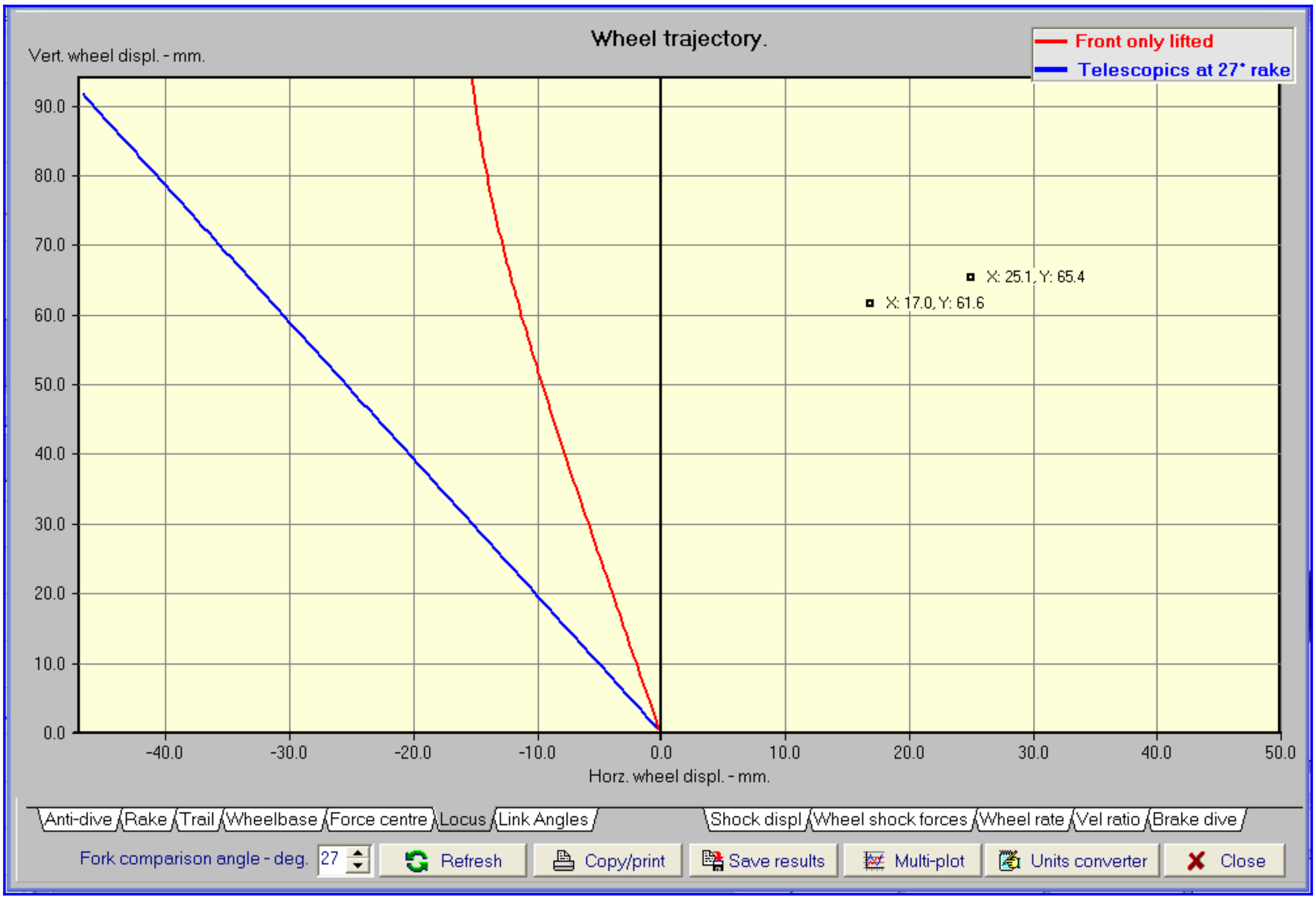



Rake angle.
Rear extended
Rear compressed
Rake angle - deg.
25.0
20.0
15.0
10.0
5.0
0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Wheel displacement - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

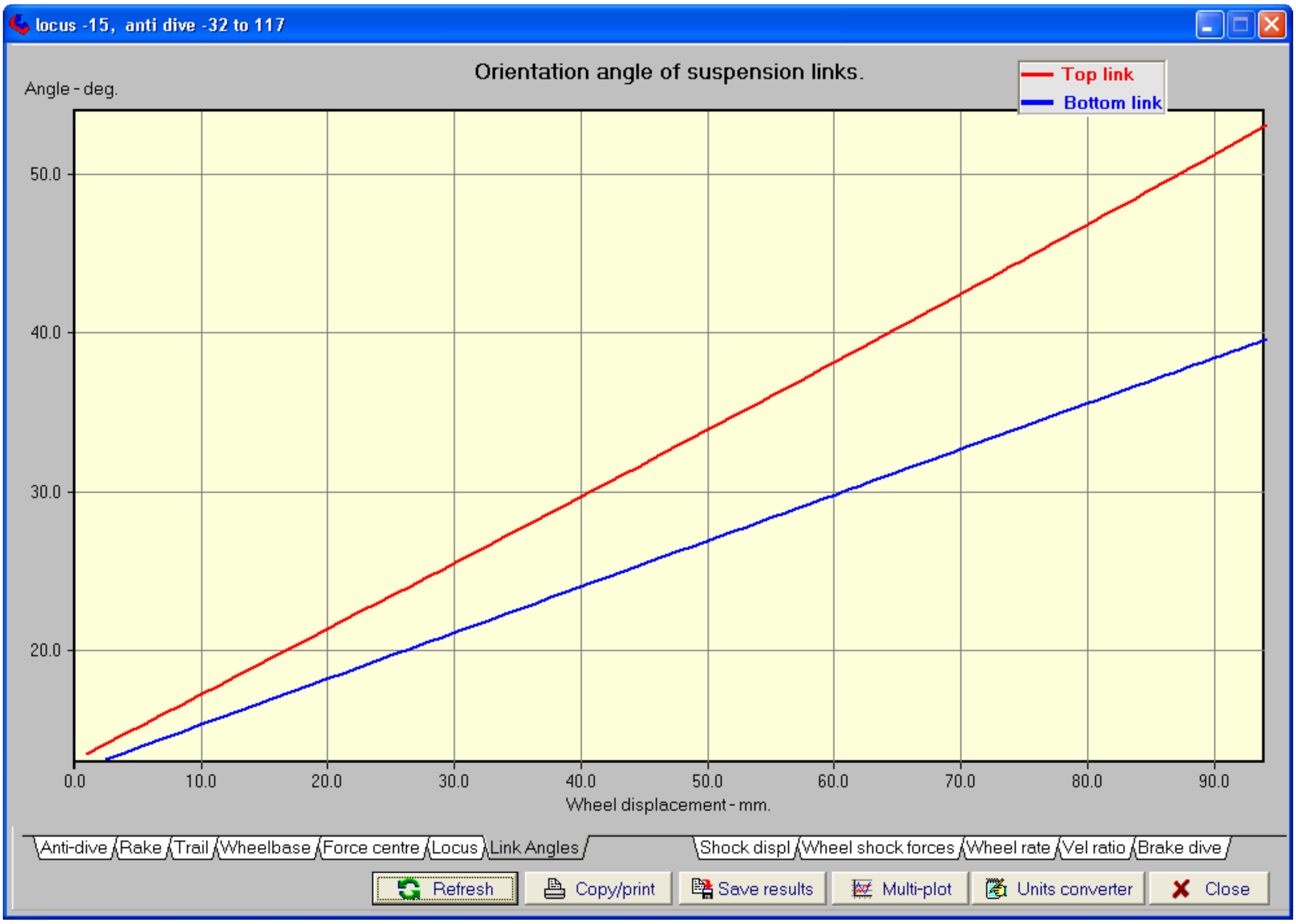

Trail.
Rear extended
Rear compressed
Trail - mm.
120
100
80
60
40
20
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Wheel displacement - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

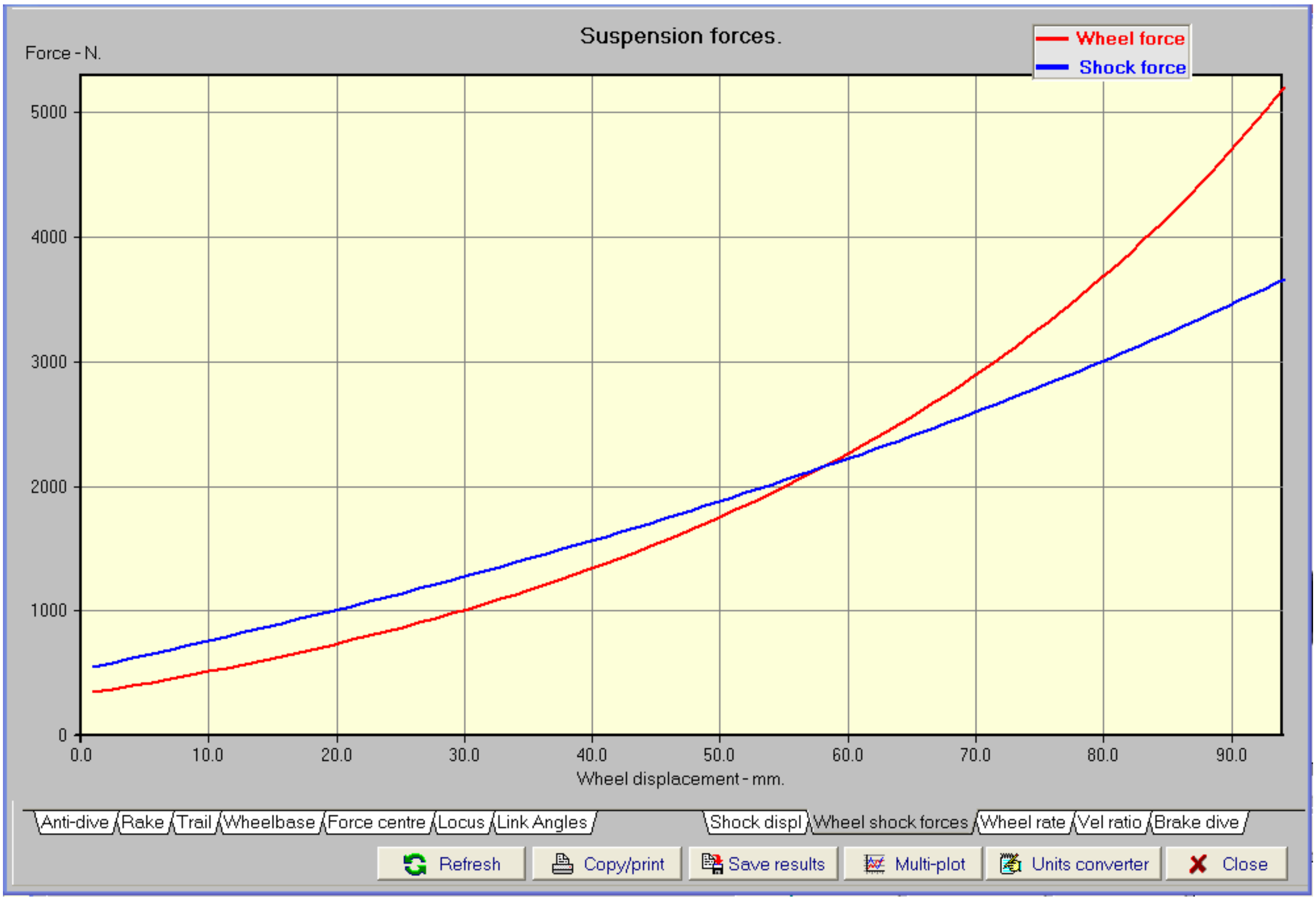


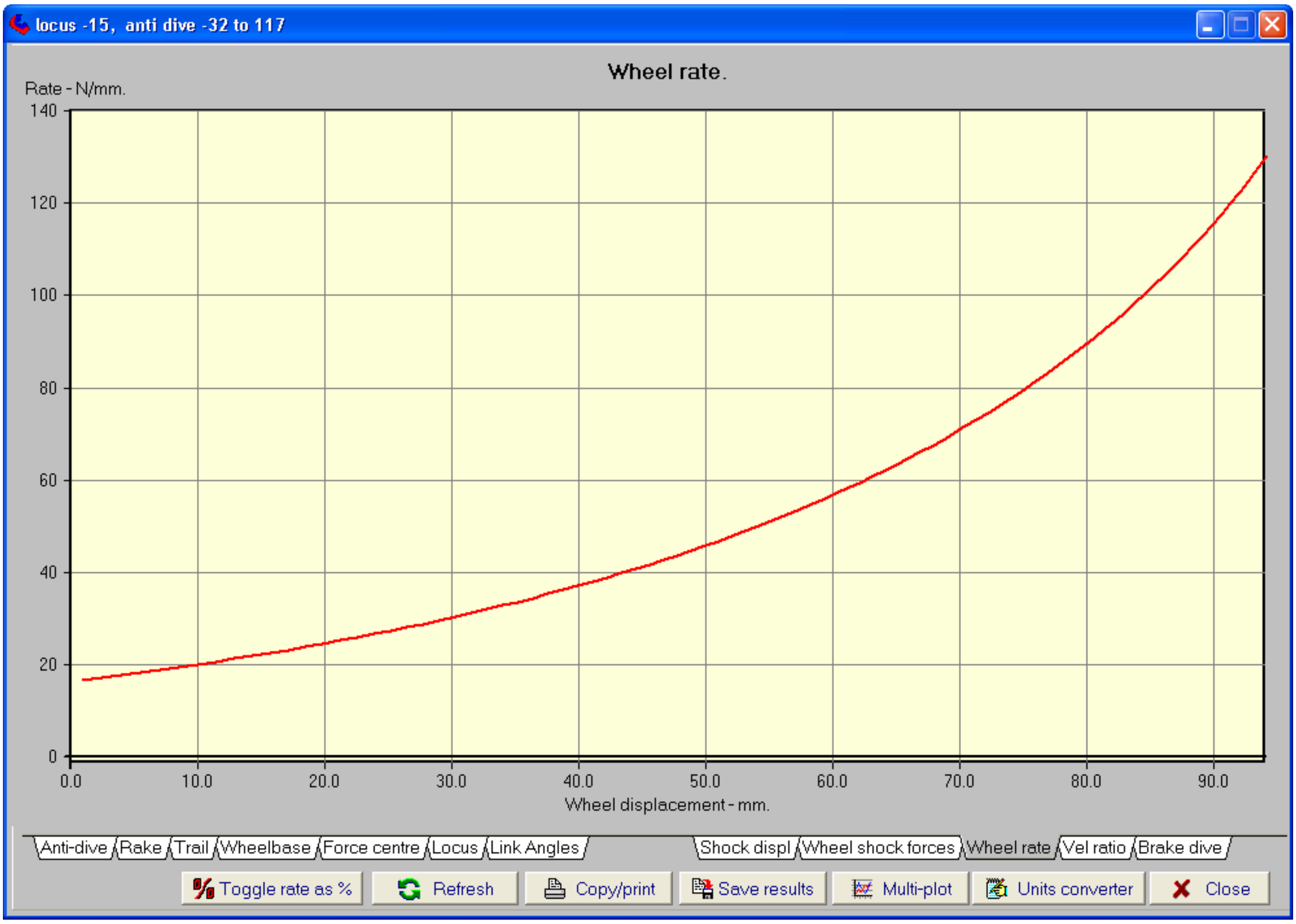
locus -15, anti dive -32 to 117
Virtual pivot locus.
Rear extended
Y coordinate - mm.
0
-500
-1000
-1500
-2000
-2500
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
X coordinate - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

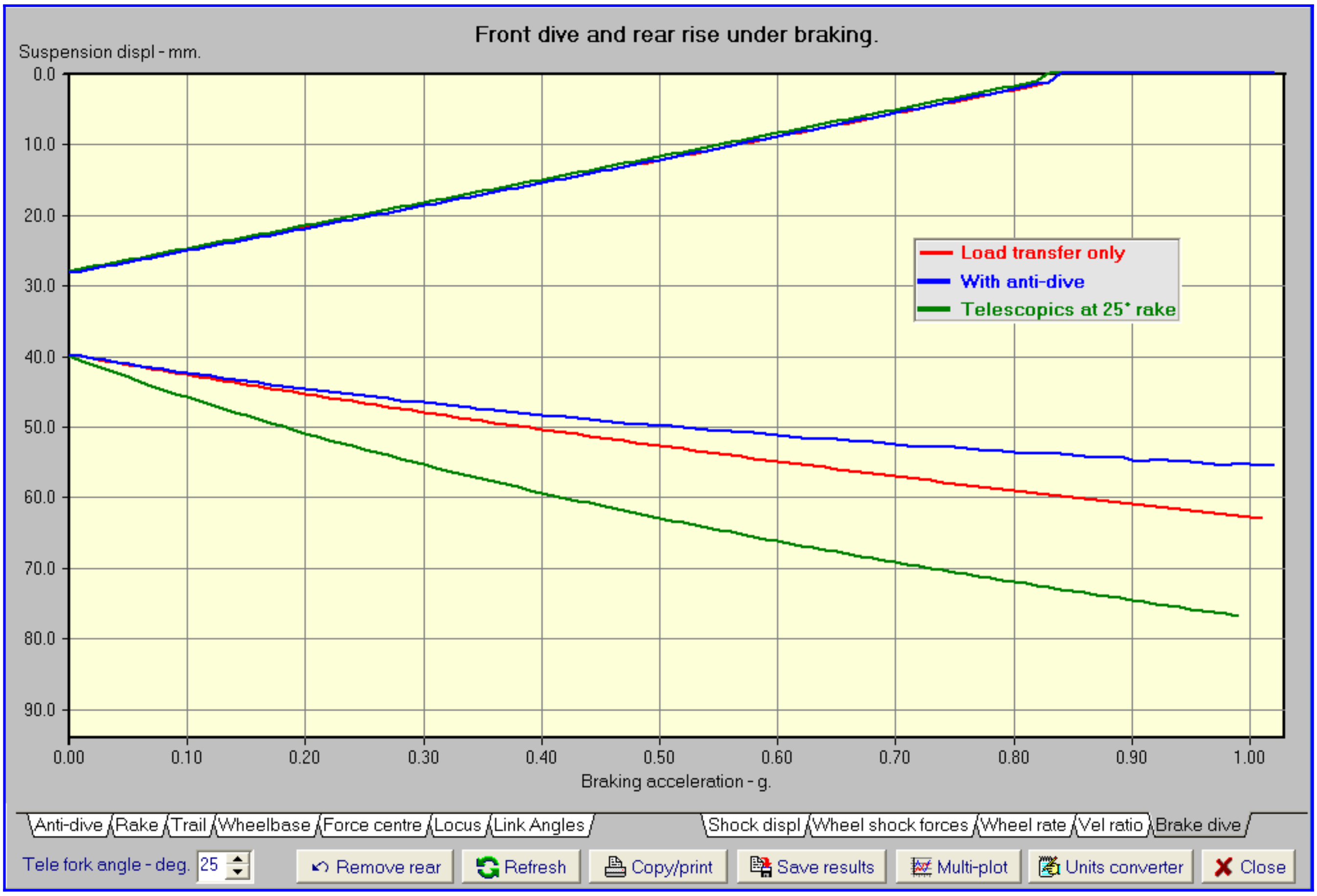


Wheel trajectory.
Front only lifted
Telescopics at 27° rake
Vert. wheel displ. - mm.
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
X: 25.1, Y: 65.4
X: 17.0, Y: 61.6
-40.0
-30.0
-20.0
-10.0
0.0
10.0
20.0
30.0
40.0
50.0
Horz. wheel displ. - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Fork comparison angle - deg.
27
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

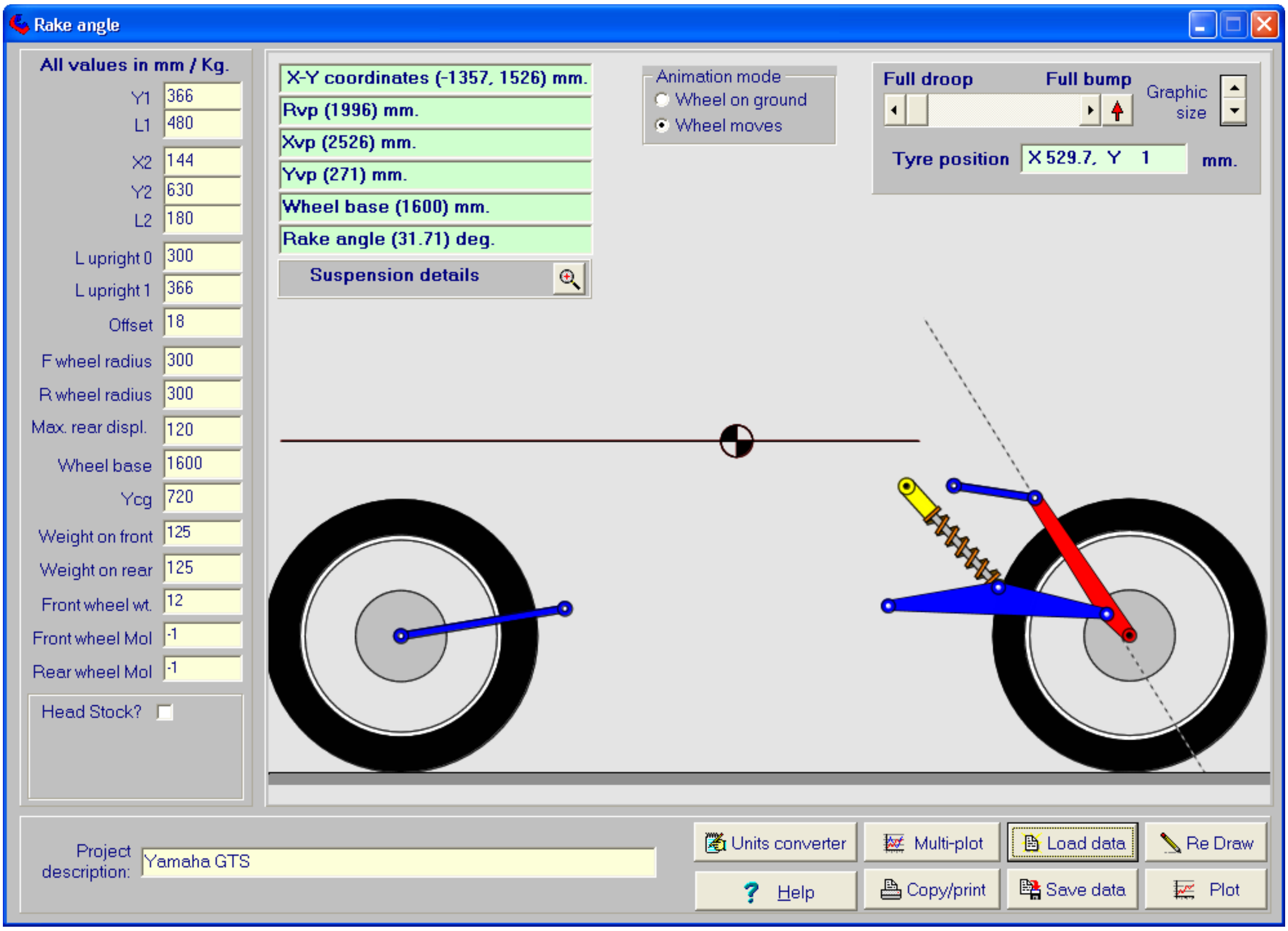

locus -15, anti dive -32 to 117
Orientation angle of suspension links.
Angle - deg.
Top link
Bottom link
50.0
40.0
30.0
20.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Wheel displacement - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

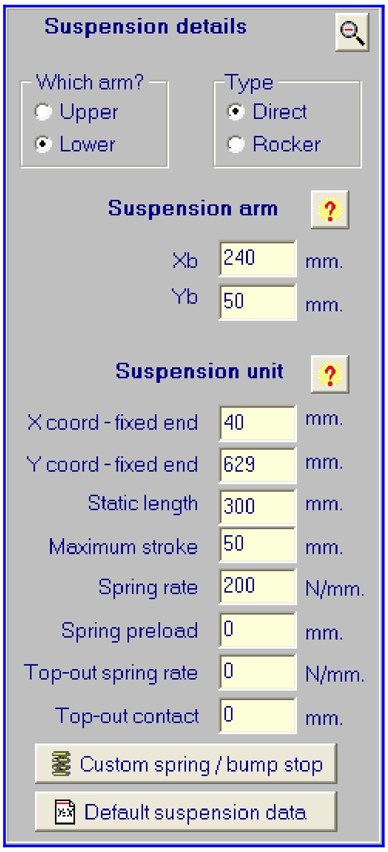

Suspension forces.
Force - N.
Wheel force
Shock force
5000
4000
3000
2000
1000
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Wheel displacement - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close


locus -15, anti dive -32 to 117
Wheel rate.
Rate - N/mm.
140
120
100
80
60
40
20
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Wheel displacement - mm.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Toggle rate as %
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

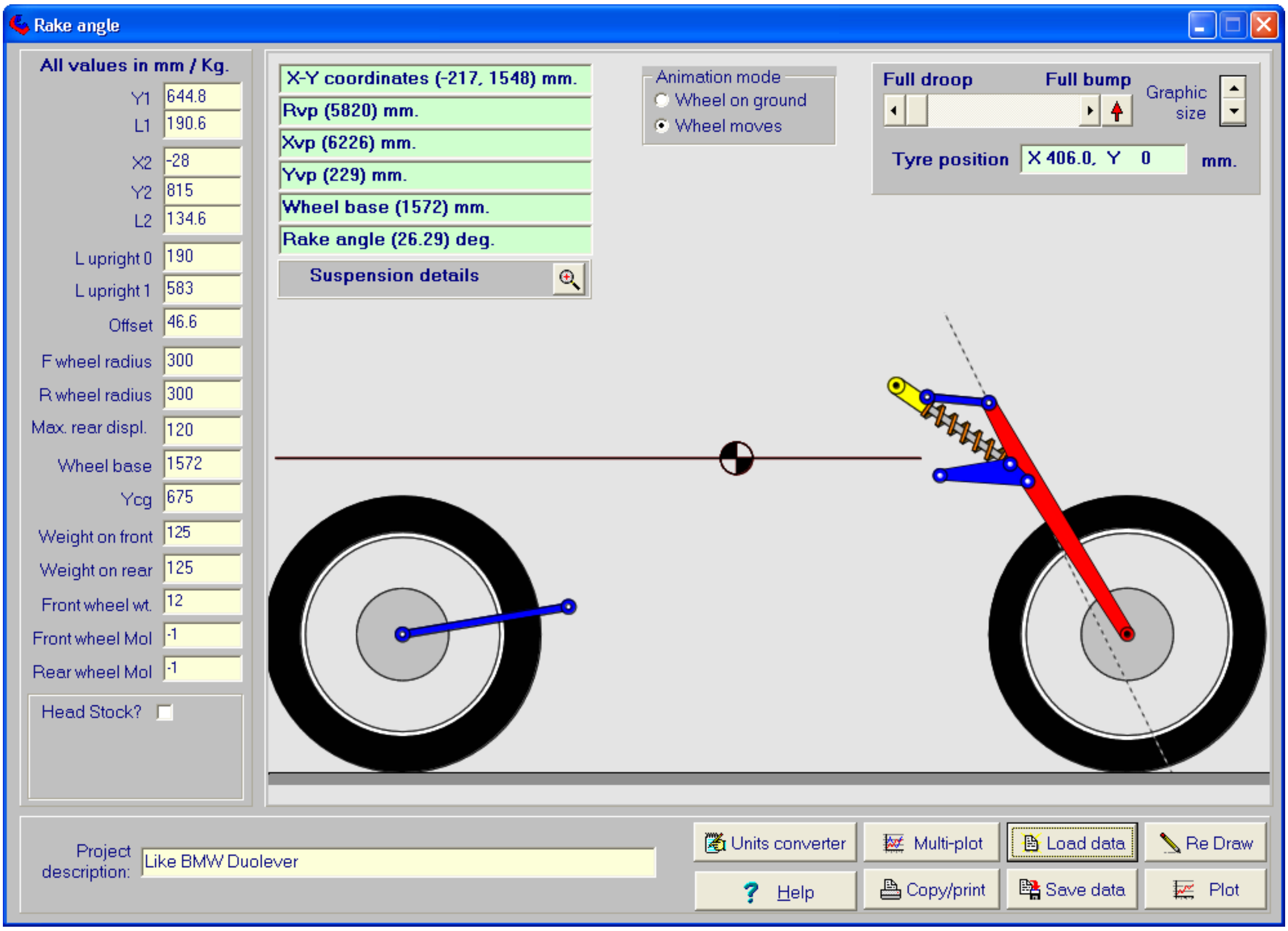

Front dive and rear rise under braking.
Suspension displ - mm.
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
Load transfer only
With anti-dive
Telescopics at 25° rake
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Braking acceleration - g.
Anti-dive
Rake
Trail
Wheelbase
Force centre
Locus
Link Angles
Shock displ
Wheel shock forces
Wheel rate
Vel ratio
Brake dive
Tele fork angle - deg.
25
Remove rear
Refresh
Copy/print
Save results
Multi-plot
Units converter
Close

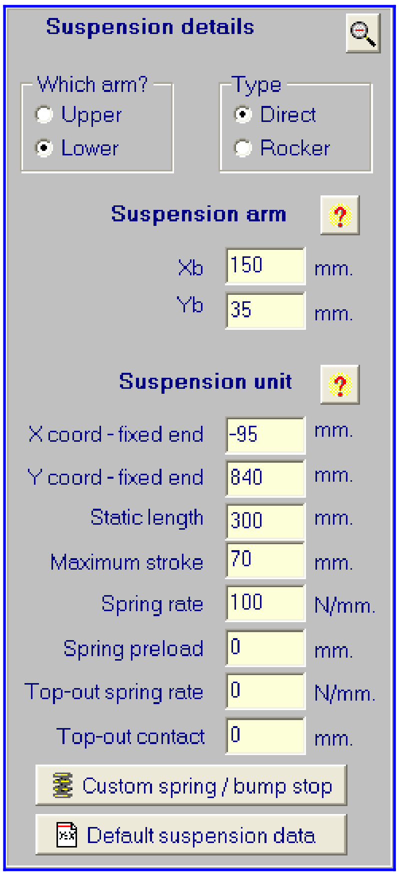
Examples of data entry. Foale/Parker/GTS system.





Hossack/BMW duolever design



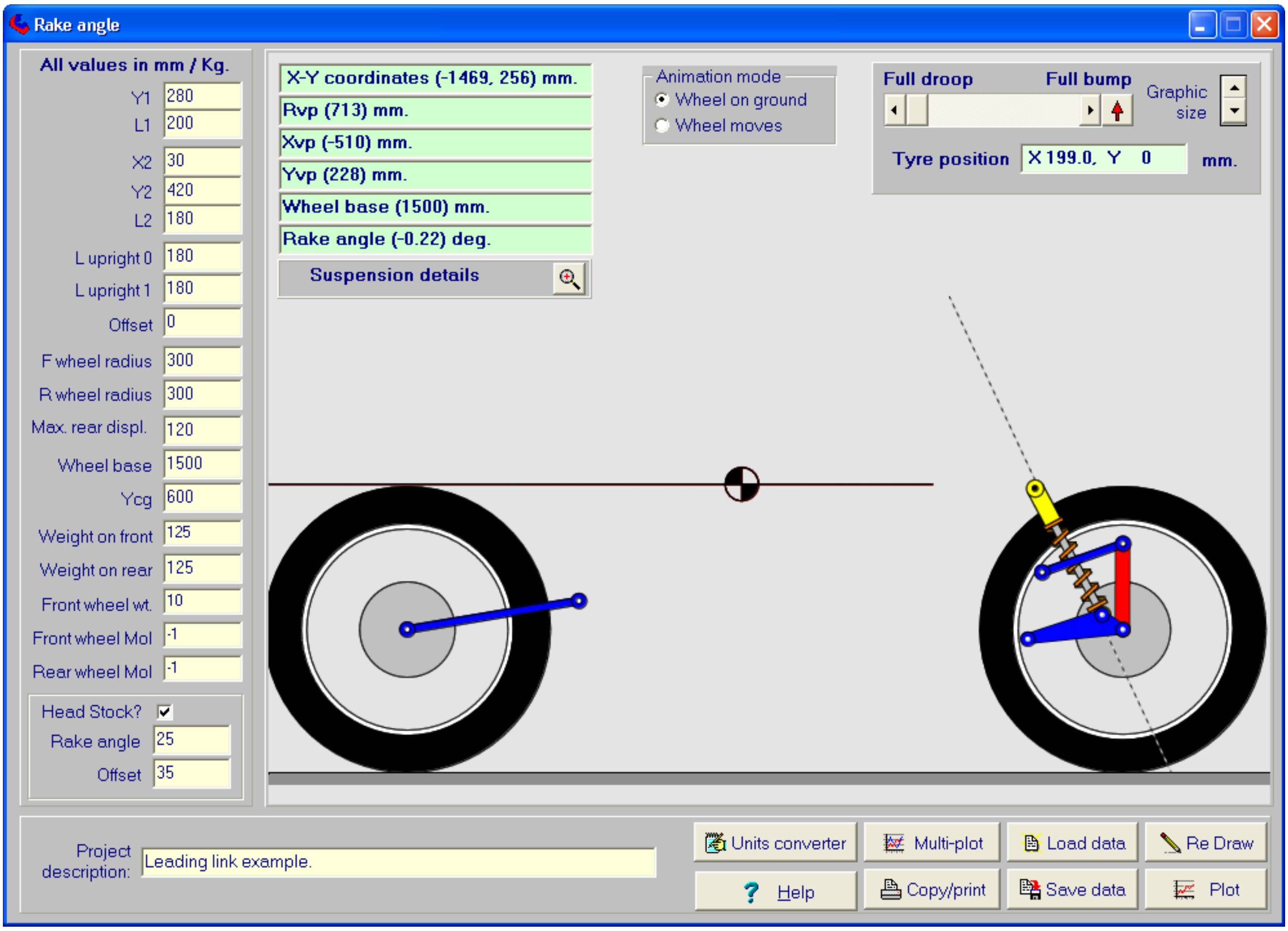


Example of Leading Link forks

Note that the two upright dimensions are equal and refer to the radius from the wheel axis to the mounting point for the torque arm on a floating back plate (for drum brakes) or caliper mounting plate.

In the case that the back plate is fixed to a single arm, such as the leading link Earles' style forks on the 1960s BMWs, you can model this design by making the rear pivots of the front (lower) swing arm and the torque arm (upper) concentric. For example using the swing arm dimensions from the example below, make **X2 = 0, Y2 = Y1 = 280**. **L2** is relatively unimportant but it would be safe to make it equal to **L1**. The upright lengths can be any size greater than zero and less than **L2**. I use a value of 1.

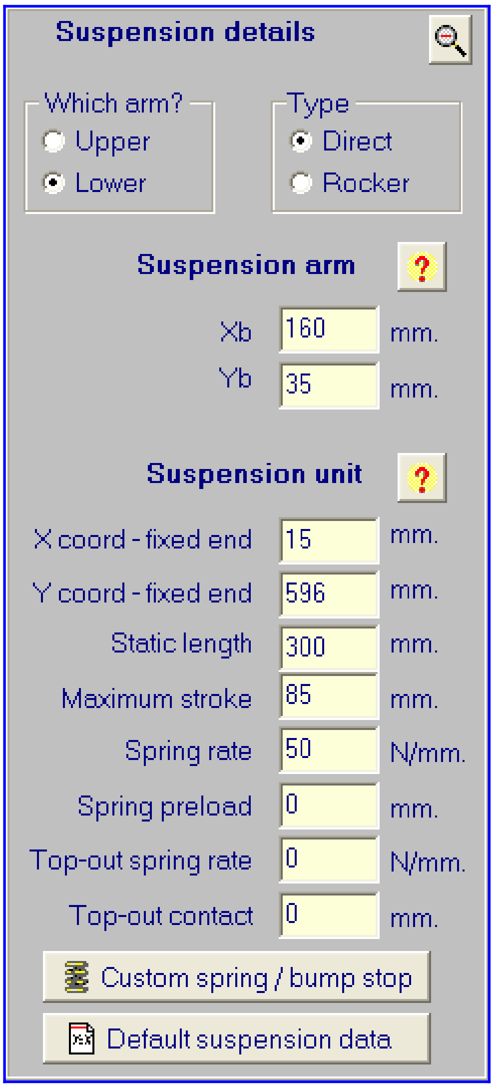
For any head stock mounted forks, the **Head Stock** box must be ticked and the values for rake angle and wheel offset need to be entered. See the later example.



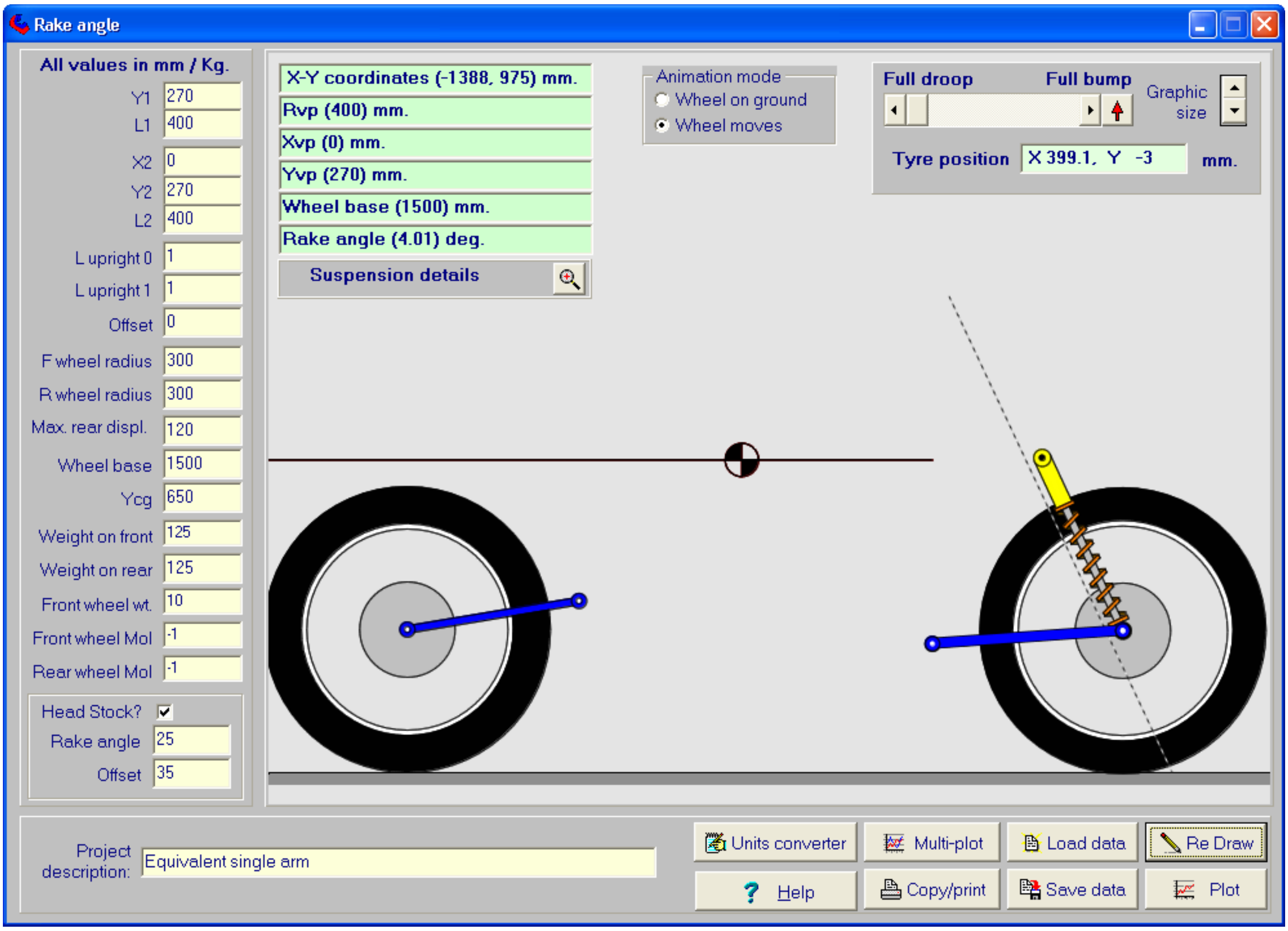
Trailing link forks

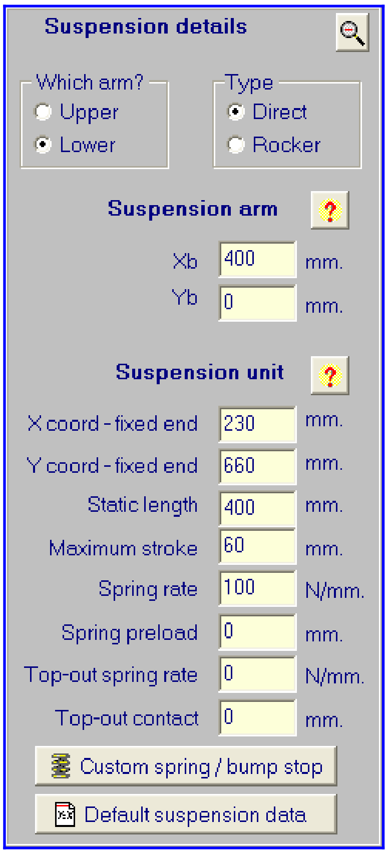
Enter the data exactly the same as for the LL type with appropriate coordinates except use a negative value for the value of **L1**, the main link. The negative value signals the software that both links are trailing.

Here is the shock data that goes with the leading link fork example above.



An example of the data for Earles' forks

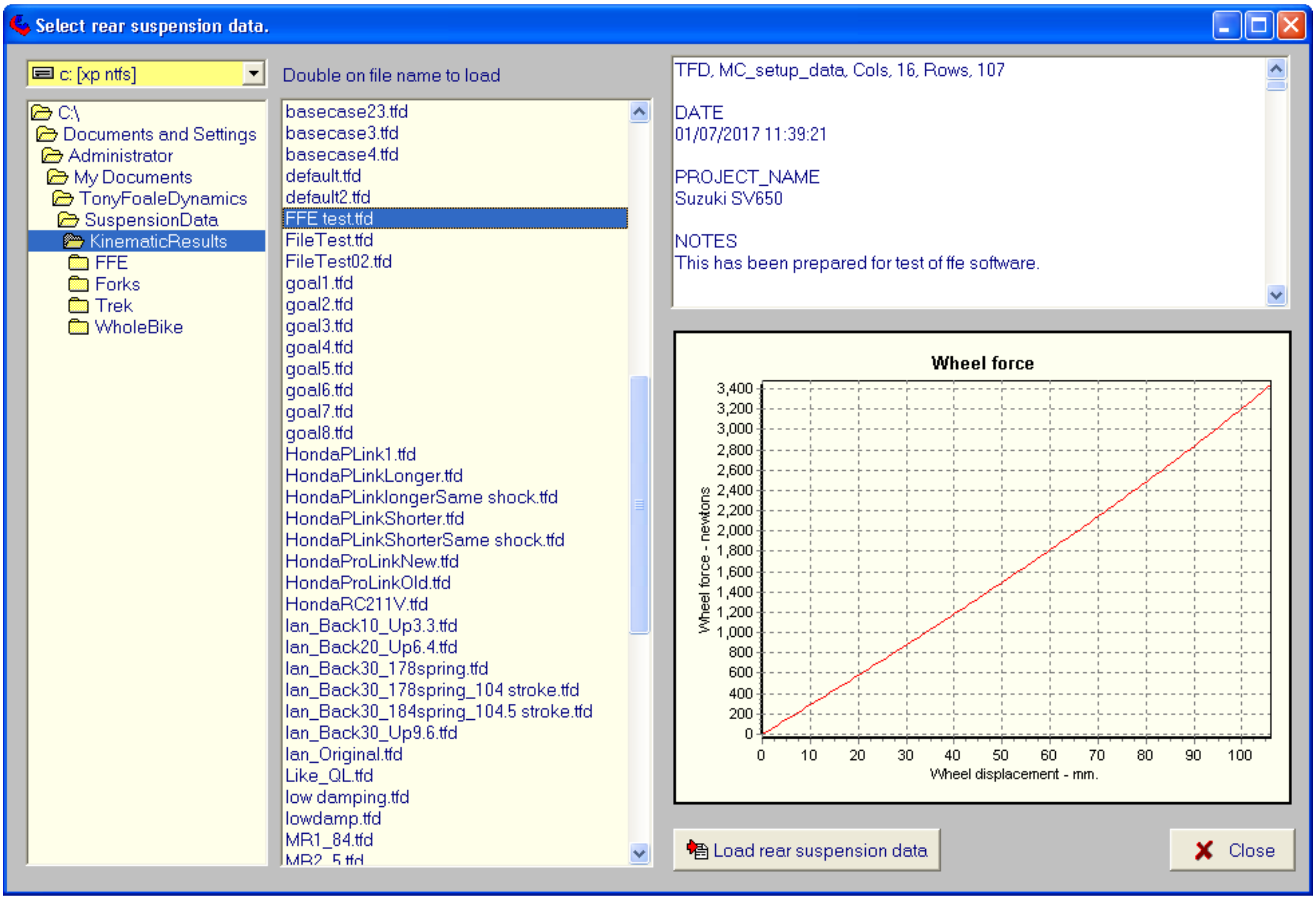




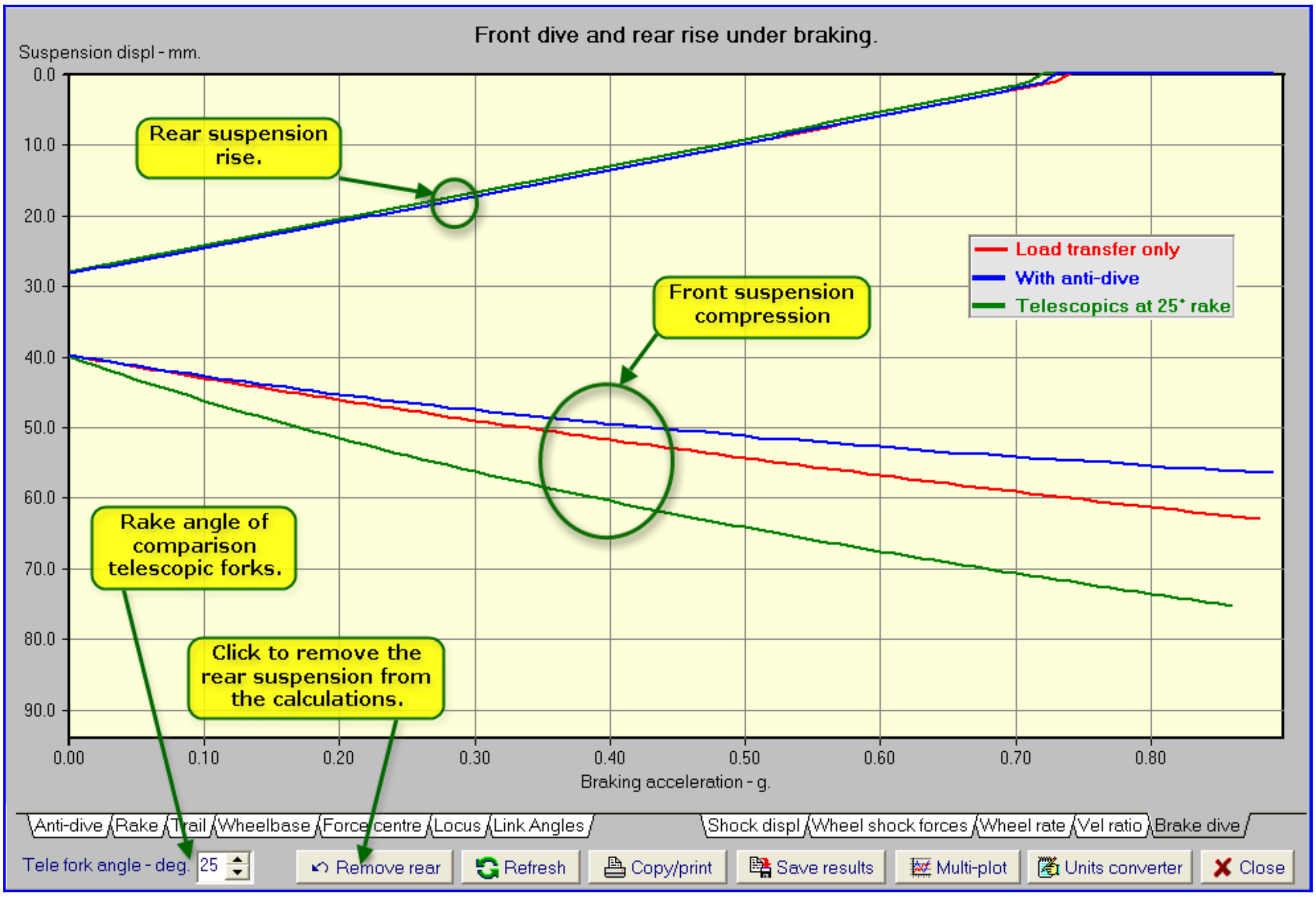
Appendix

This appendix describes in detail the use of the other software features.

Use this if you have the "Whole bike" software loaded on the same computer. It will give you access to previously saved rear suspension data. Select the required file from the list as follows. You will see a graph and information about the data which helps decide if it is the file that you want.



This will be used in the braking dive calculations which will also plot the rear suspension movement under braking as shown below. If the rear suspension data is not imported then the calculations will be done with the rear suspension set at full extension.

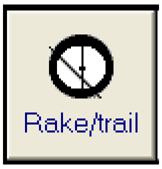


This is the results plot of the dive calculations including the displacement of the rear suspension under the influence of front wheel braking only. The lower blue line represents the actual dive to be expected and takes into account the anti- pro-dive characteristics of the design being analysed. The other lower lines are purely for comparative purposes. The red line shows the dive that would occur if dive was only dependent on load transfer alone. This would be the equivalent of a zero anti-dive percentage. The green line shows the dive to be expected from telescopic forks set to an angle specified by the number at the lower left. The calculations for the 0% anti-dive case and the telescopic case use the same effective vertical wheel rate as the actual case in blue.

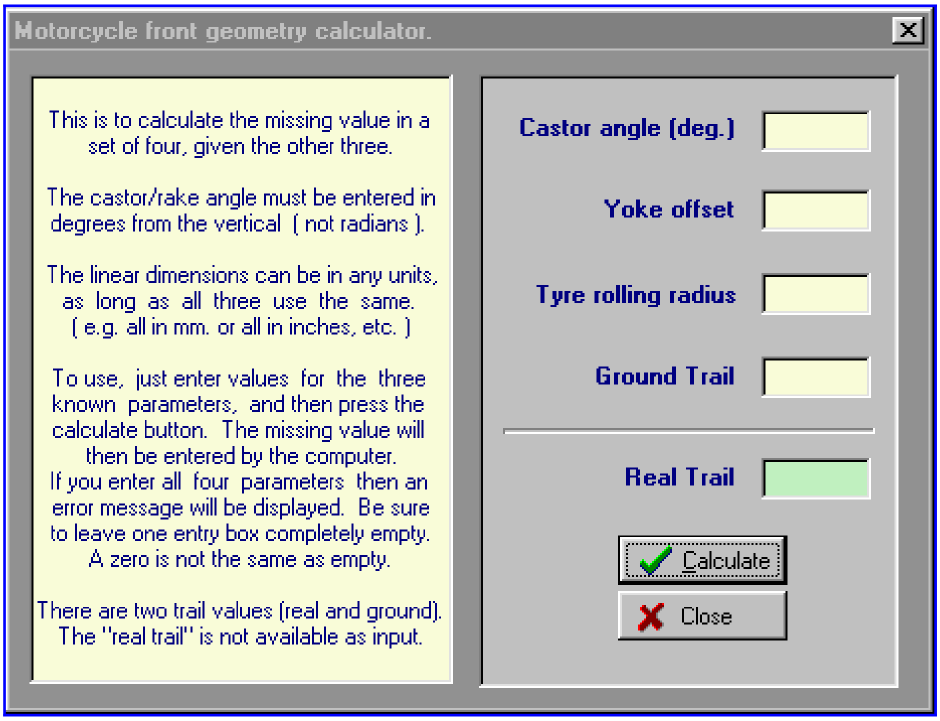
Note that three graphs end at slightly different braking decelerations. Each case stops at the deceleration that would cause the rear wheel to lift off the ground. These thresholds are determined by how the CG height and wheelbase vary with deceleration. It can be seen that the case with the telescopic forks reaches the threshold at lower decelerations, this may seem odd as the greater dive reduces the CG height more. This is true but that effect is overwhelmed by the amount that the wheelbase is shortened from the front due to the relatively large rearward component of the fork's displacement.

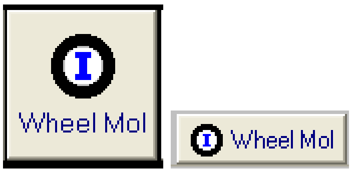
As can be seen, the response of the rear suspension is less affected by the characteristics of the front.

Only the actual case (the blue graph) is saved for viewing in the multi-plot feature. To create plots similar to the above it will be necessary to set the "Gbrake" parameter as the X-axis and the "WheelDis" as the Y-axis. For other saved parameters it would be usual to set "WheelDis" (Front wheel displacement) as the X-axis.



This is a simple tool to perform rake and trail calculations. Enter data into any three of the four data entry boxes, click on “Calculate” and it will calculate the fourth parameter. For example, if you know the required rake and trail values and wheel size then it will calculate the required offset necessary to give those values.





This is a wheel polar moment of inertia calculator.

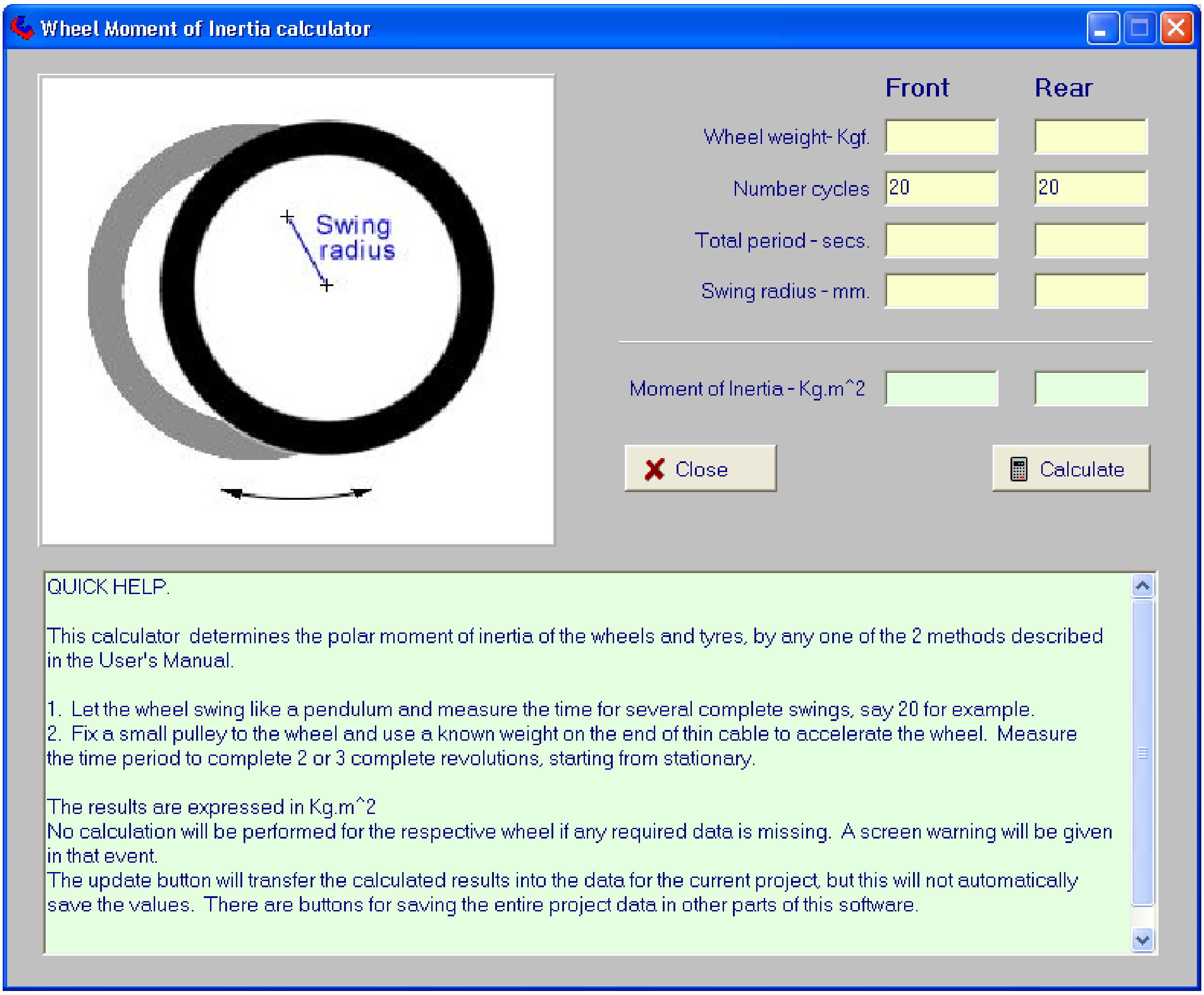
The wheel moments of inertia are used in the calculation of the anti-dive characteristics.
This calculator is really two in one. It can calculate the moments of inertia for two different methods of physical measurements.

The accuracy of the MoI values do not have a large effect on the anti-squat values, they are just a refinement to the calculations not a major part. In many cases the MoI values will not be available, if you do not have this information, use the value –1, which loads default values into the calculations based on typical wheels according to their weight. These default values will normally be sufficient.

It is not difficult to measure the actual moments of inertia. There are many different ways of doing this depending on the facilities available, but these calculators do the hard work for two simple methods of measurement. They can be described as:

1. Swinging pendulum
2. Pulley and weight

Swinging pendulum



The following photos show how the wheel needs to be mounted off-centre such that it can swing from side to side about an axis defined by the supporting bar. In cases where there is no convenient symmetrical supporting locations (rear wheels and single disc fronts), the wheel can be supported by the bar just under the rim section.

The distance between the swing axis and the axle centre needs to be measured. The wheel should be slightly displaced to one side and allowed to swing back and forth like a pendulum. Measure the time required to complete a number of complete cycles, 20 for example to reduce the effect of timing errors. A swing amplitude of +/- 5 degrees is quite sufficient.

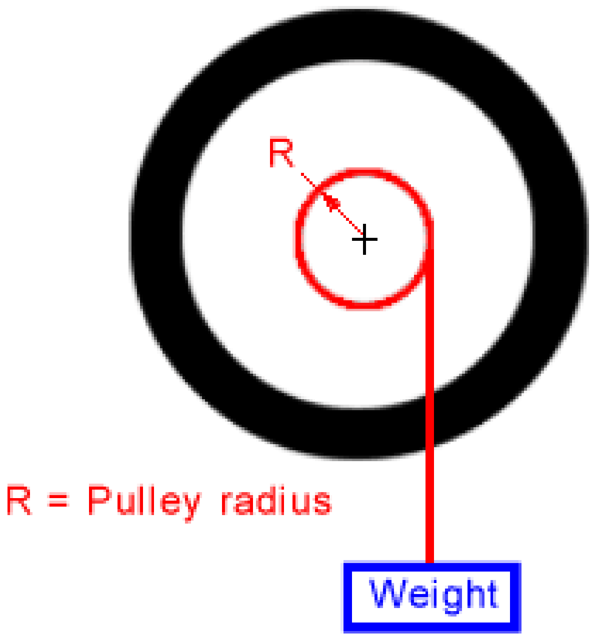
This method has the advantage that only the minimum of equipment is needed to do the measurements. Apart from a stopwatch, weighing scales and a ruler or vernier calipers, a bar strong enough to support the wheel without excessive flex (10 mm. diameter is usually sufficient) and some means of supporting the bar horizontally is all that's necessary.

Pulley and weight

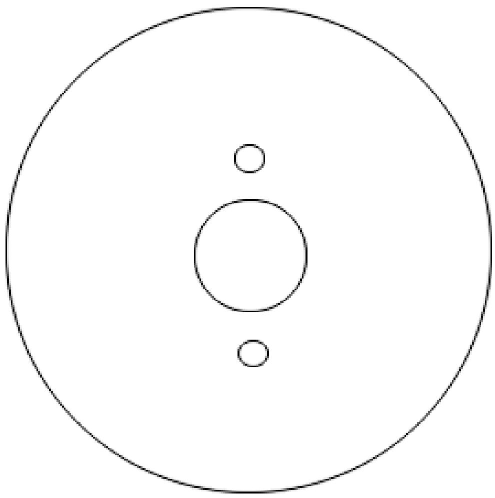
Probably the most accurate method of the two, but requires a little more preparation. A small pulley (about 100 mm diameter is ideal) needs to be made that can be attached to the wheel, concentric with its spin axis. Some thin cord or flexible cable is wound around the pulley and the free end attached to a known weight (2 kg. for example). Using this method the wheel can be supported with its own axle which must be mounted sufficiently high to allow the weight to fall the equivalent of two or more wheel revolutions. Using a pulley of 100 mm diameter, the weight will fall just over 0.3 metres for each revolution.

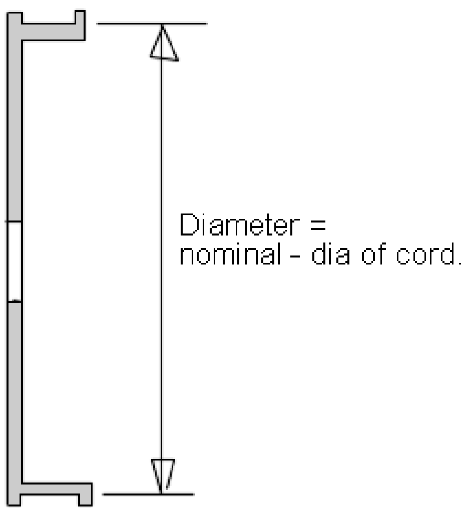
The pulley should be a light as possible so that it contributes a minimum to the MoI of the wheel, although in most cases it will be a simple matter to calculate its own MoI and subtract from the overall value, but this is usually not necessary.

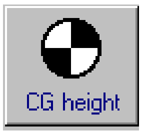
Layout of pulley and wheel



Sample pulley design.



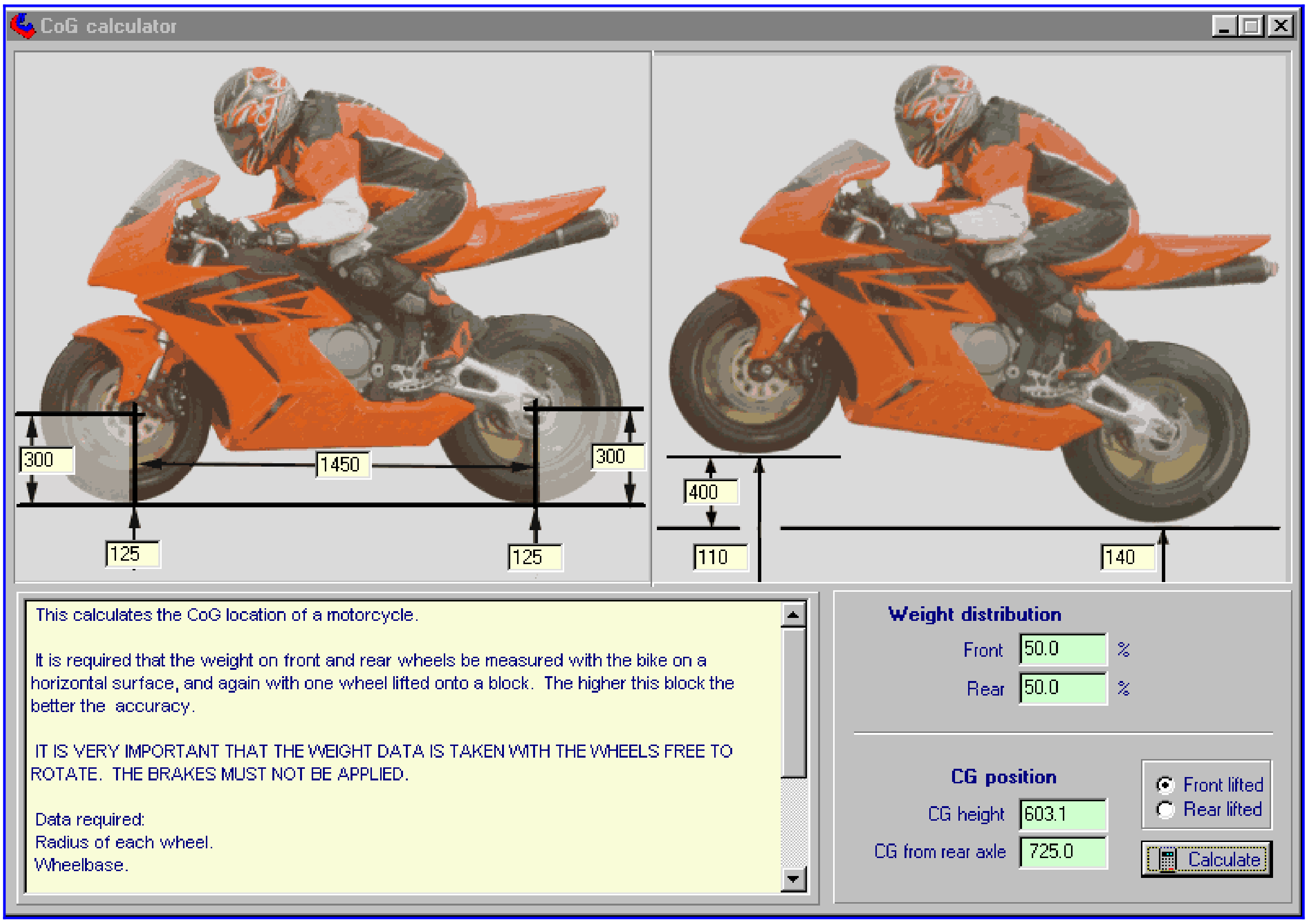




The CG height is an important parameter needed for the analysis of motorcycle setup. There are various ways to measure this but most need facilities outside of those readily available.

The simplest is to weigh each end of the machine when level and when lifted onto a block at one end. This calculator will then calculate the CG position. You can toggle the calculator depending on whether you raise the front or rear of the motorcycle. It is usually easier for the rider to raise the front end.

A help window is built into the screen and warnings are given if input data is not mutually compatible.



Saving and loading data

There are two types of data that can be saved in the software.

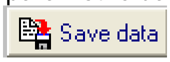
Parametric (project data).

Calculated results.

The parametric data refers to the physical parameters of the motorcycle. For example, upright dimensions, wheel size etc.

The calculated results are the characteristics of the system being analyzed such as anti-dive, wheel trajectory etc.

Parametric (project data)

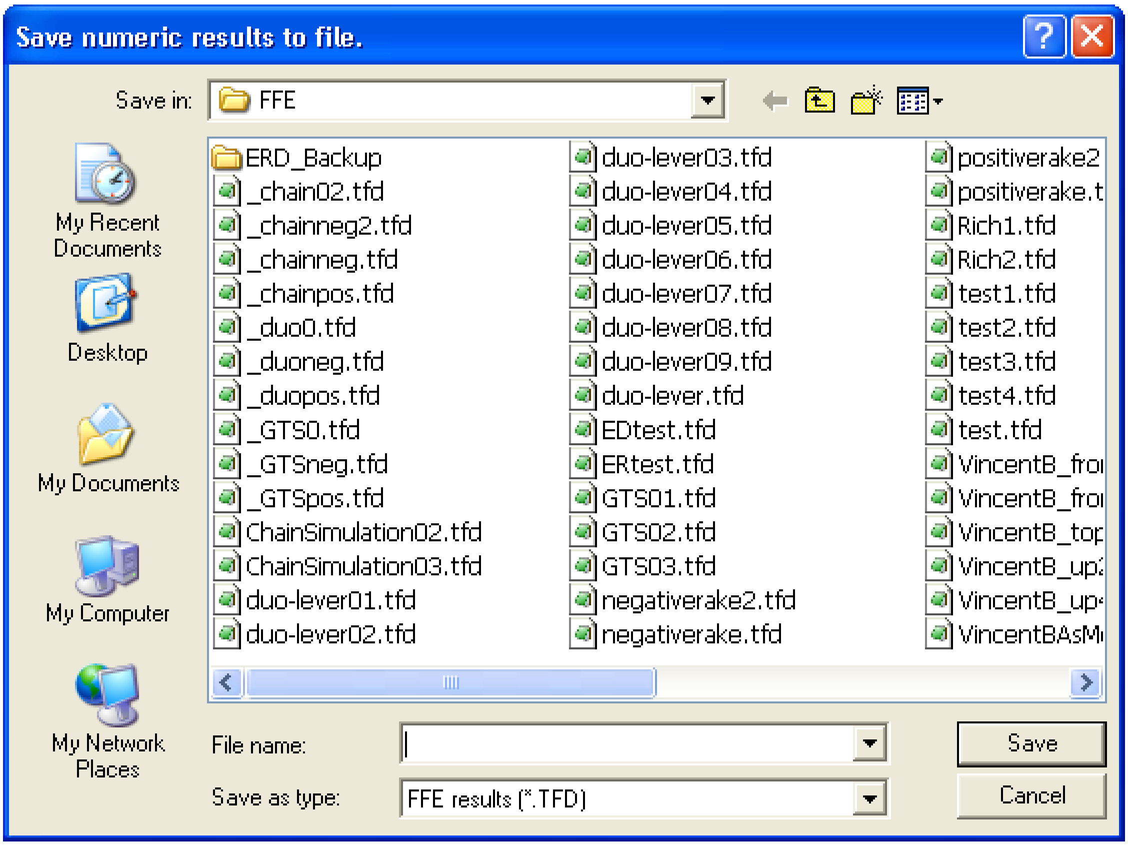
The data is stored in the concept of a "project" . A project represents all the parametric data for a particular front suspension layout. Saving and loading parametric data is just a question of selecting a file name and confirming, as per usual software practice. Use the 

button on the principal screen

Saving calculated results

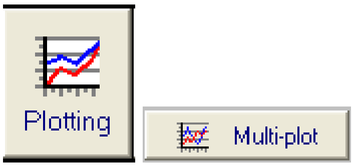
These can be saved by clicking on the 

button at the bottom of the results graphs.



When saving both the parametric and calculated data it is suggested that you use a file name that will help identify the case when you return to it in the future.

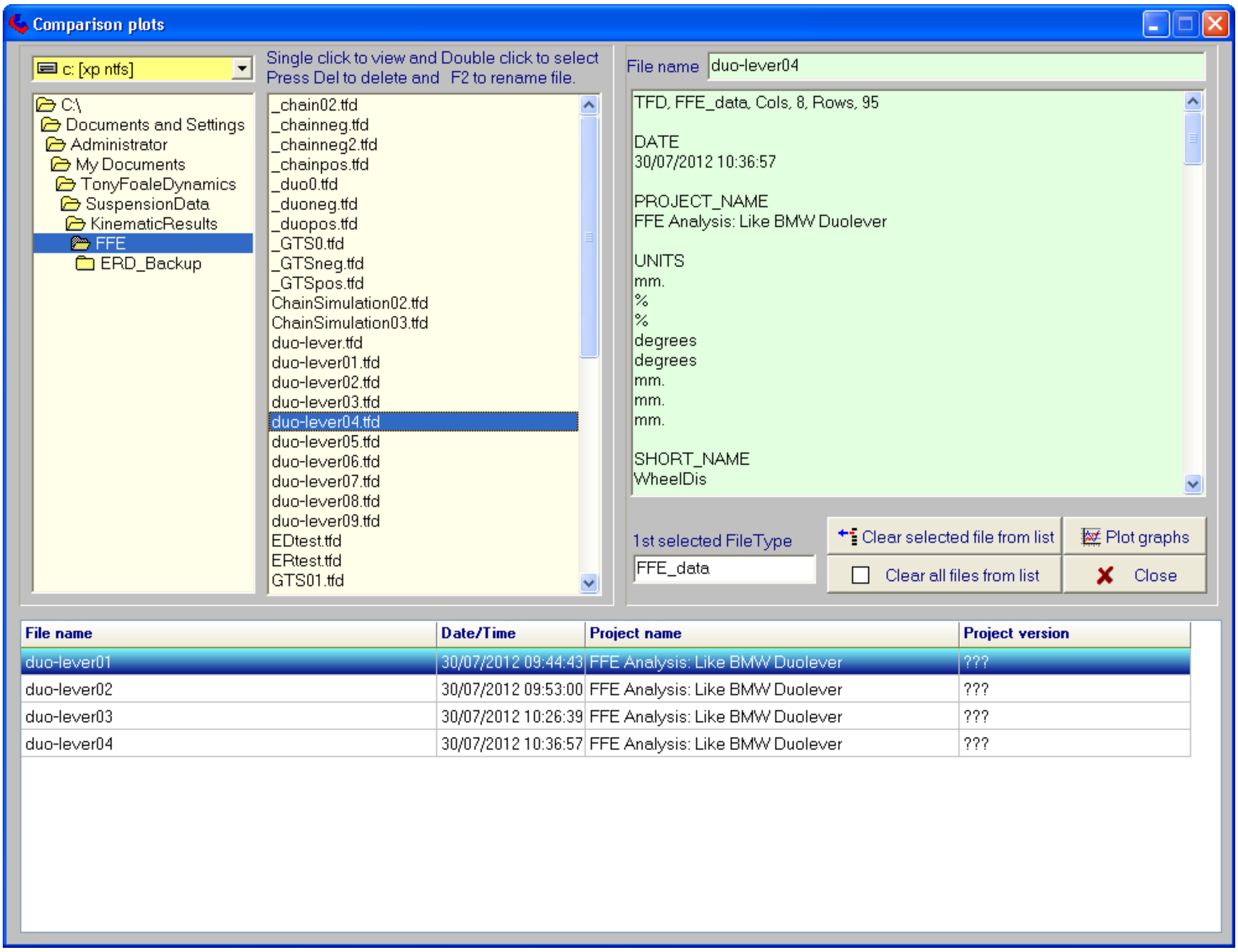
Multi-plotting



These access buttons are on both the principal screen and the results pages. They open a selection screen for choosing up to ten saved results files for comparative plotting.

The window will initially open into the default file save directory. You can navigate to other directories if you saved the files elsewhere

The second column will display a list of saved files. Click on those which you wish to compare (up to a maximum of ten), and they will appear in the plotting list across the bottom. There are buttons to remove files from this list or clear it altogether. Click on the “Plot graphs” button when you have listed the files of interest, three in this example.

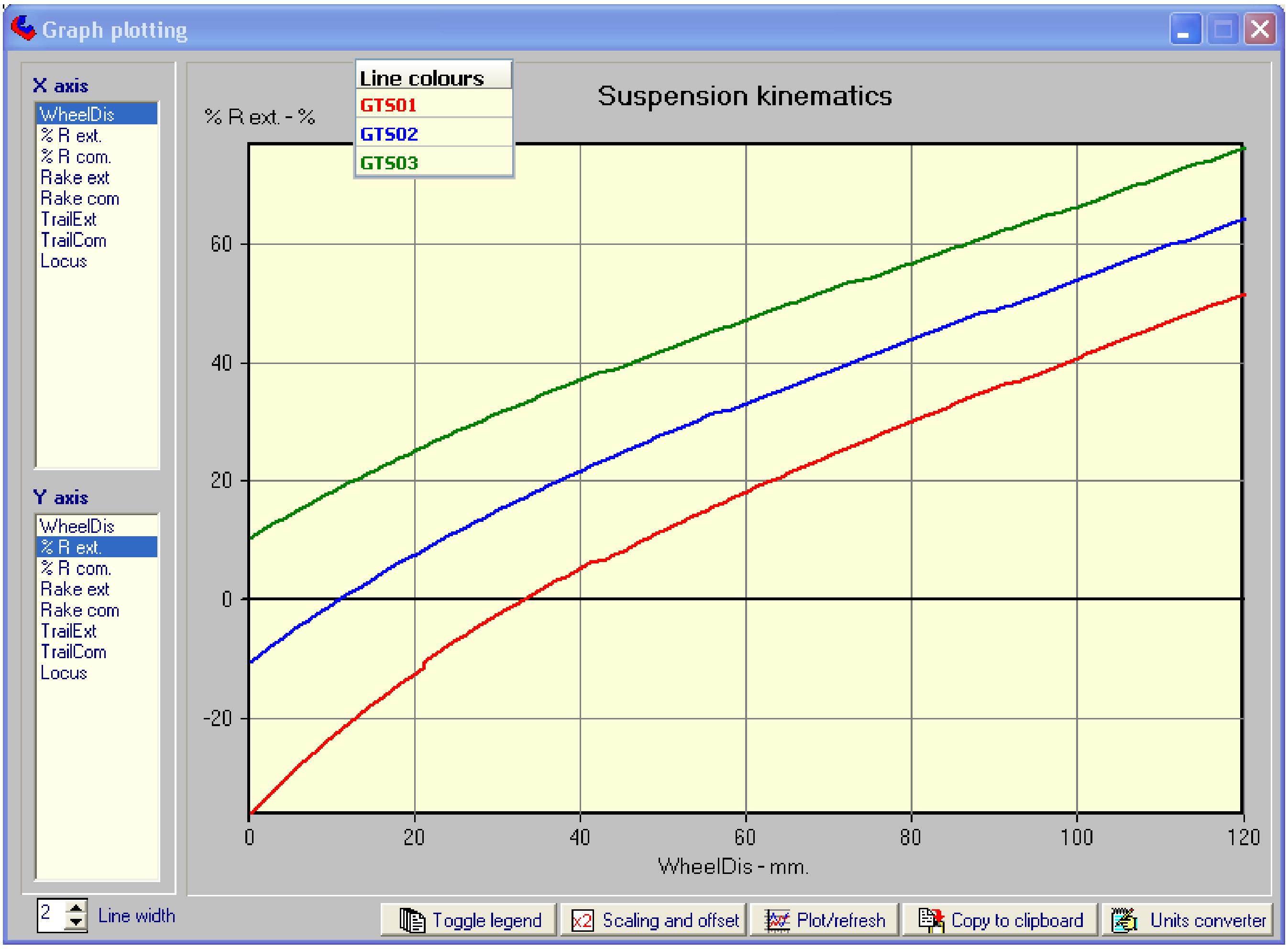


The plotting window (shown next) has three areas.

On the left are two lists of the parameters which can be plotted. The top one selects the parameter for the X axis, usually the Wheel displacement. The lower one selects the Y axis. The graphs will change dynamically as you select different plotting parameters.

Along the bottom of the window, are some buttons with fairly obvious significance, except perhaps for the "Scaling and offset". Occasionally it is useful to be able to scale or offset the data before plotting.

The main area on this window is the plotting area which plots the chosen parameter from each of the selected files.



On the plotting window, above, the area to the left shows that the wheel displacement has been chosen for the X axis and the anti-dive percentage, with the rear suspension extended for the Y axis. The three graphs show this parameter pair for the three files selected from the previous screen.

This multi-file plotting feature is extremely useful for comparing different design iterations and is also very fast and easy to use.