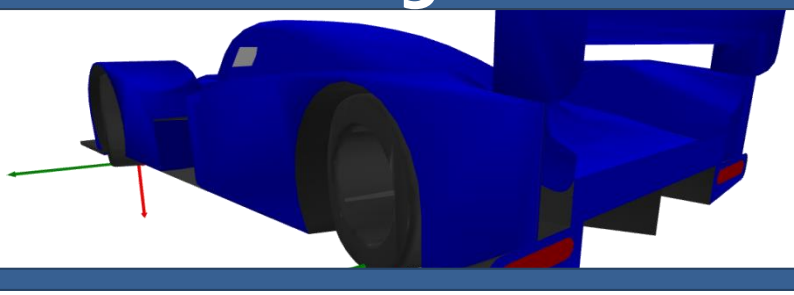
OptimumG

Tutorial 1 – Creating a Vehicle Setup



Welcome to OptimumDynamics!
In this Tutorial we will be going step by step to make your first Vehicle setups! You will learn about the OptimumDynamics Library, how to make vehicle components, and how to make a vehicle setup.
Let's get started!

Learning Objectives

Estimated Time 45 min

By the end of this tutorial you will be able to:

1. Create components
    a. Organize into folders
    b. Create assemblies of components
    c. Import data to create components
2. Use vehicle setups
    a. Create
    b. Export
    c. Import
    d. Copy-paste
3. Use the design library
    a. Import components to the vehicle setup
    b. Export components from the library to vehicle setup

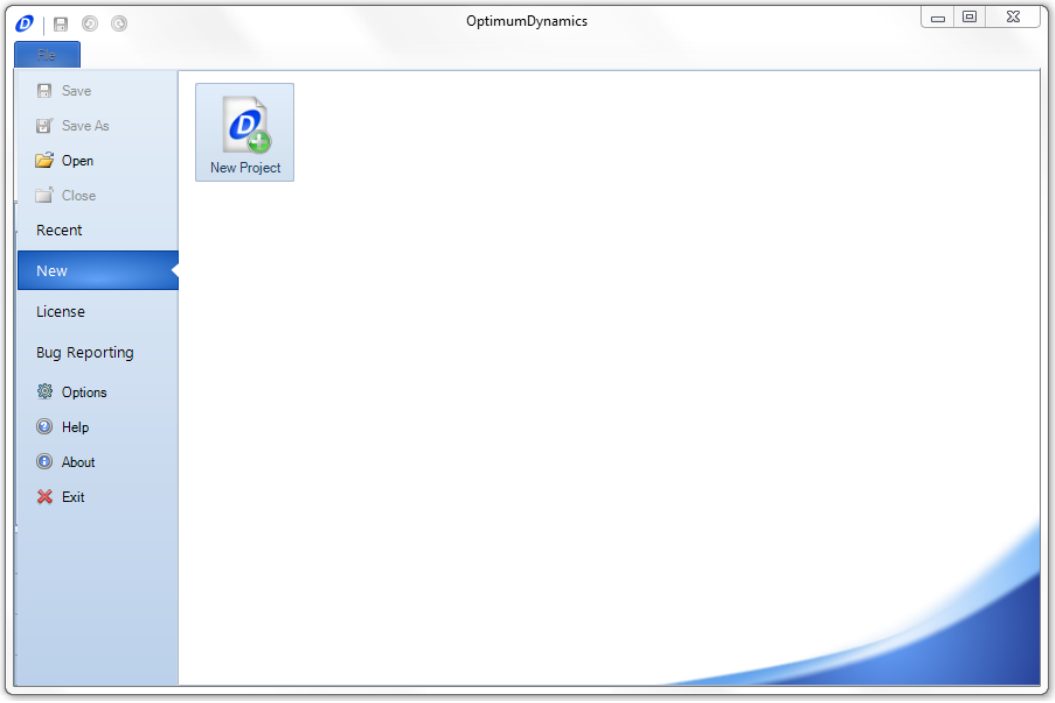
Contents

Creating a project

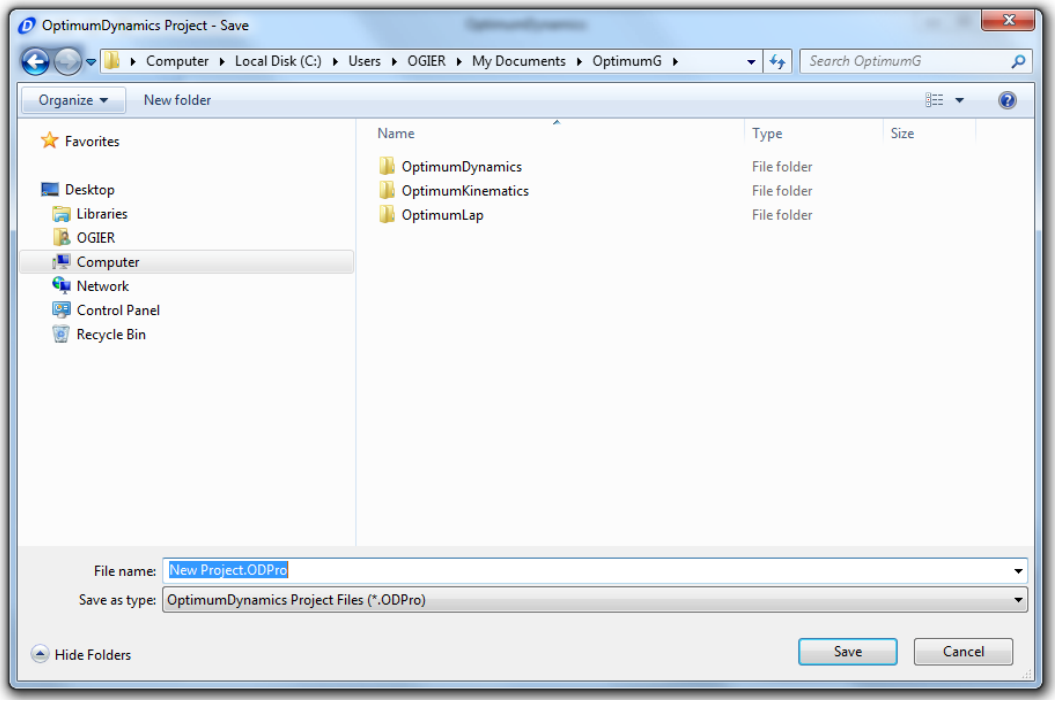
Tutorial 5% Done

Let's start off by creating a new project for the tutorial. When you first start OptimumDynamics you will see the project **Backstage**.

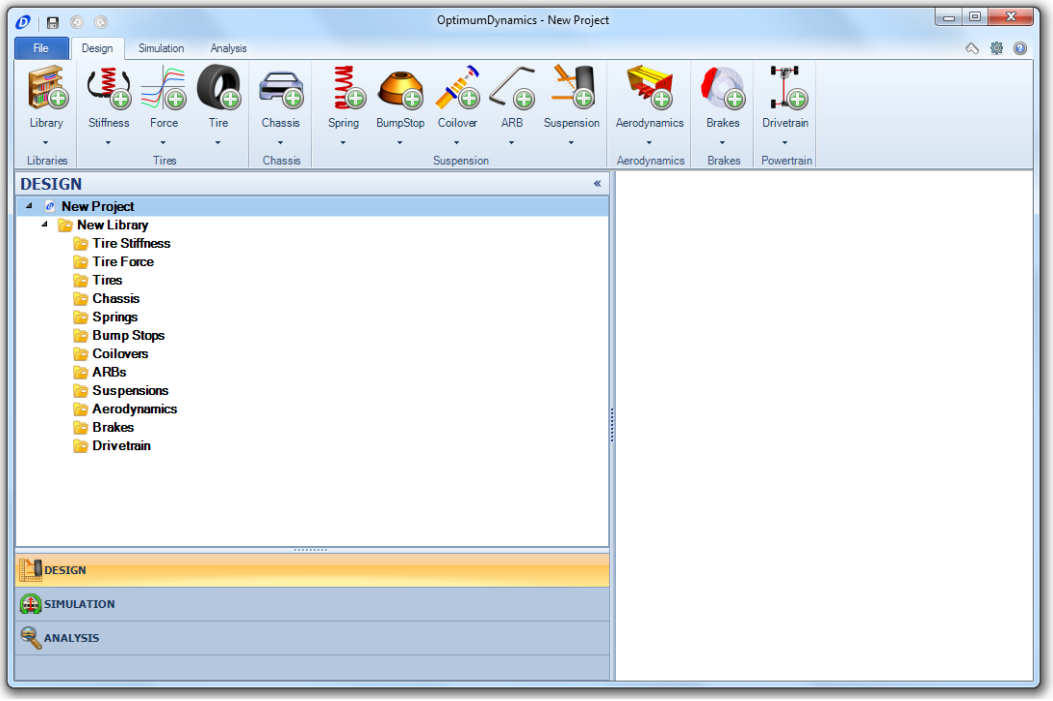
1. Click **New Project**.



2. Type in *Tutorial 1* as the **file name** and select a **file location** to save the project



Once you have created the project you will find yourself in the main graphical user interface (GUI) screen. At the top of the screen you will see the **Ribbon Control** menu. To the left of the screen is the **Project Tree.** To the right of the screen is the **Document Manager.**



Optimum Dynamics is setup so you work from left to right in the ribbon control. In this tutorial we will follow this process working across the ribbon control to design a vehicle.

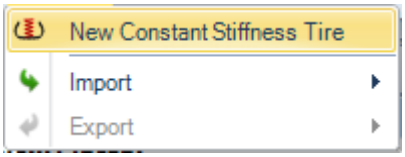
The first section in the **Ribbon Control** is the **Tire** section.

Creating a Tire Stiffness

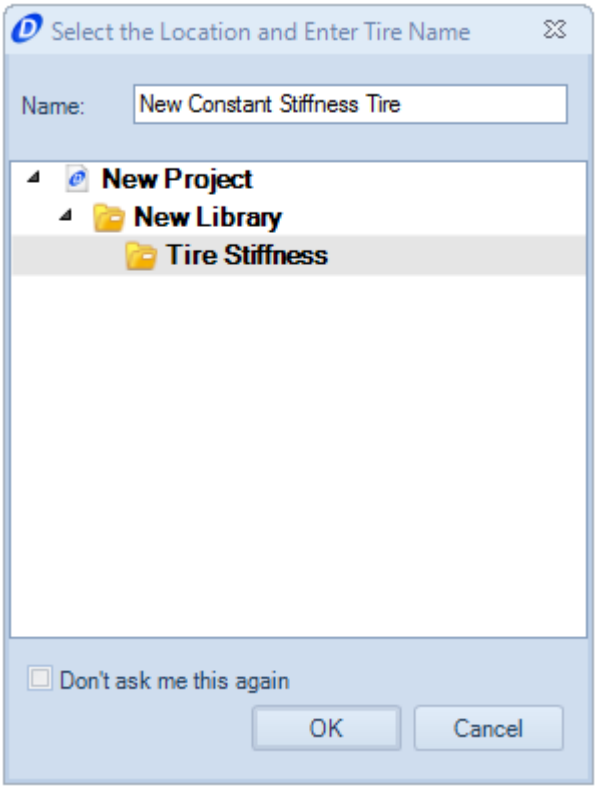
We start by creating a tire stiffness model. Modelling of the tire stiffness is necessary so that the tire deflection can be accounted for. The constant tire stiffness model assumes that the tire vertical stiffness is a constant and unchanging parameter. To create the model:

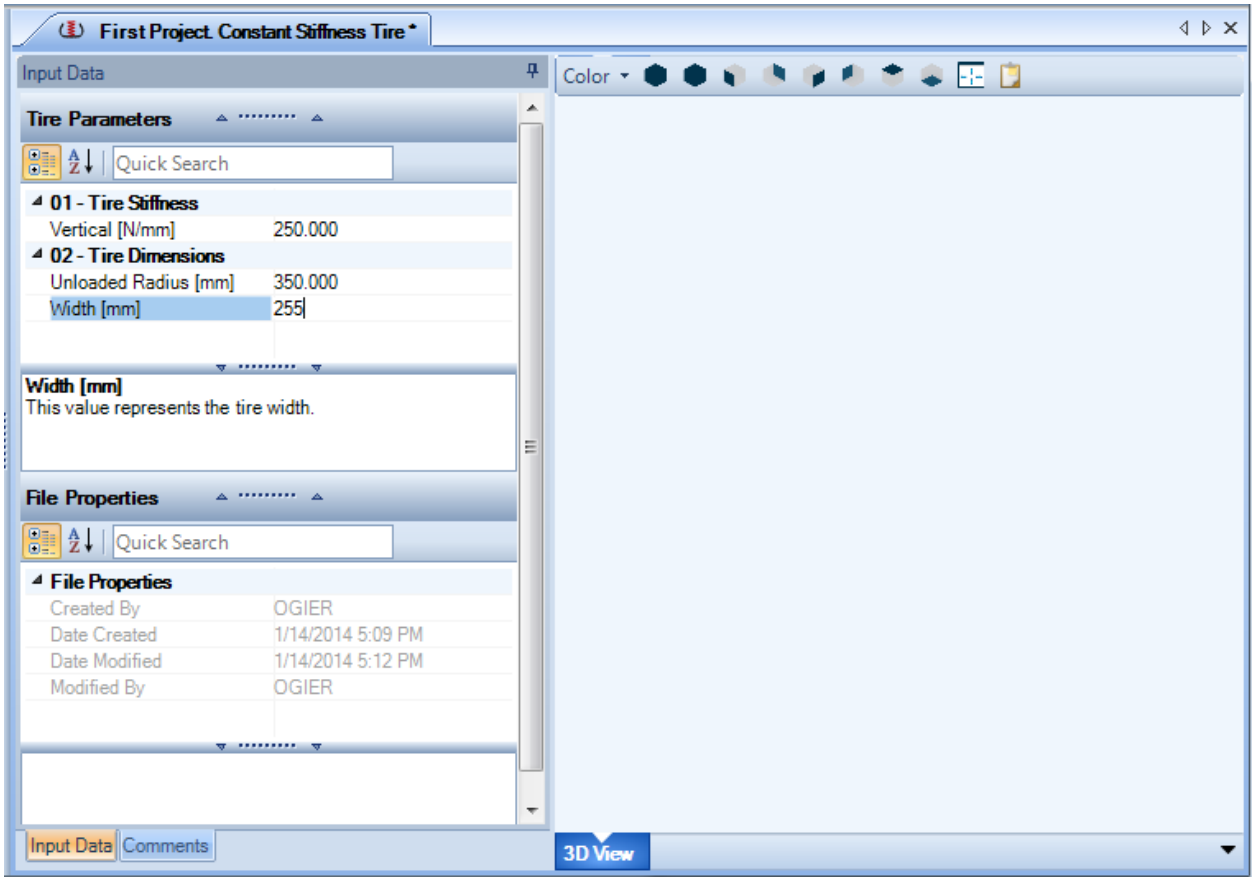
1. Click on the **Stiffness** button in the **Tires** section.

2. Click on **New Constant Stiffness Tire.**



3. Name your **Stiffness model** and click OK. The **Stiffness model** will save in the **Tire Stiffness** folder in the **Library.**





The inputs will show in the **Document Manager** section of the GUI.

Enter the **Vertical Stiffness**, **Unloaded radius**, and **Width** of the **Tire** as seen in the above image. Notice the tool tip that appears in the lower box of the **Tire Parameters** section. This tooltip box gives some useful information about what information to input.

Notice the asterisk that appears after the tab name. 

This indicates that an input has been modified but has not yet been saved.

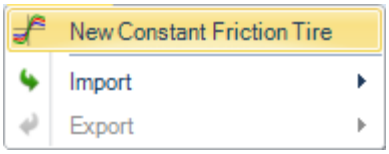
4. Press the **Save button** or press "Ctrl+S" to save the project. Notice that the asterisk is now gone. You should save your project frequently to reduce the risk of lost data.

   At the far right of the **Document Manager** there is a **Close** button.
   You can choose to close component documents to reduce the number of open tabs.

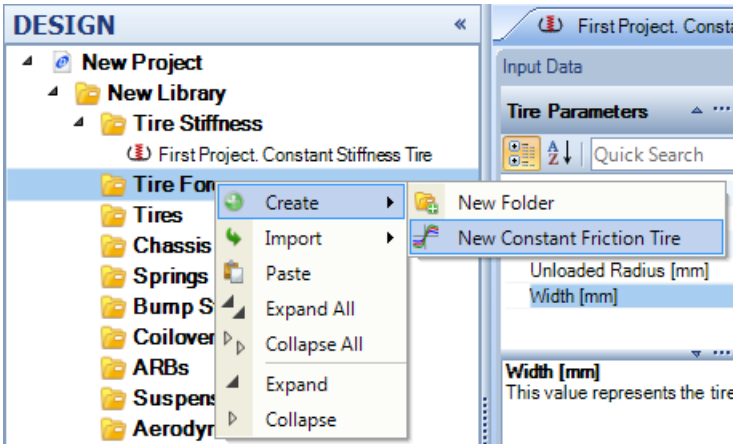
The vehicle simulation in OptimumDynamics relies on knowing the actual forces generated at the tire contact patch for each wheel. To achieve this some form of a tire model is required. The constant friction tire is the simplest type of tire model that OptimumDynamics offers.

1. Since we are working from left to right in the ribbon we should now press the **Force** button in the **Tires** section.

2. Click on **New Constant Friction Tire.**

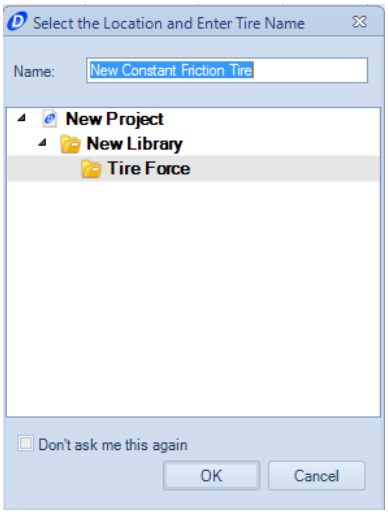


3. Press Cancel on the box that appears
4. Alternatively we can right click the **Tire Force** folder in the **Project Tree**. A list of options will appear. Click **Create** to expand choices further, and click on **New Constant Friction Tire**.



Any object can be created using this method by right clicking on its respective folder.

5. Choose a name for the **Tire force model** and click the **OK button**.



6. Enter a **friction limit** of **1.7** for the tire. The coefficient defined describes the maximum combined lateral and longitudinal friction factor.

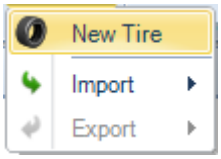
Creating a Tire

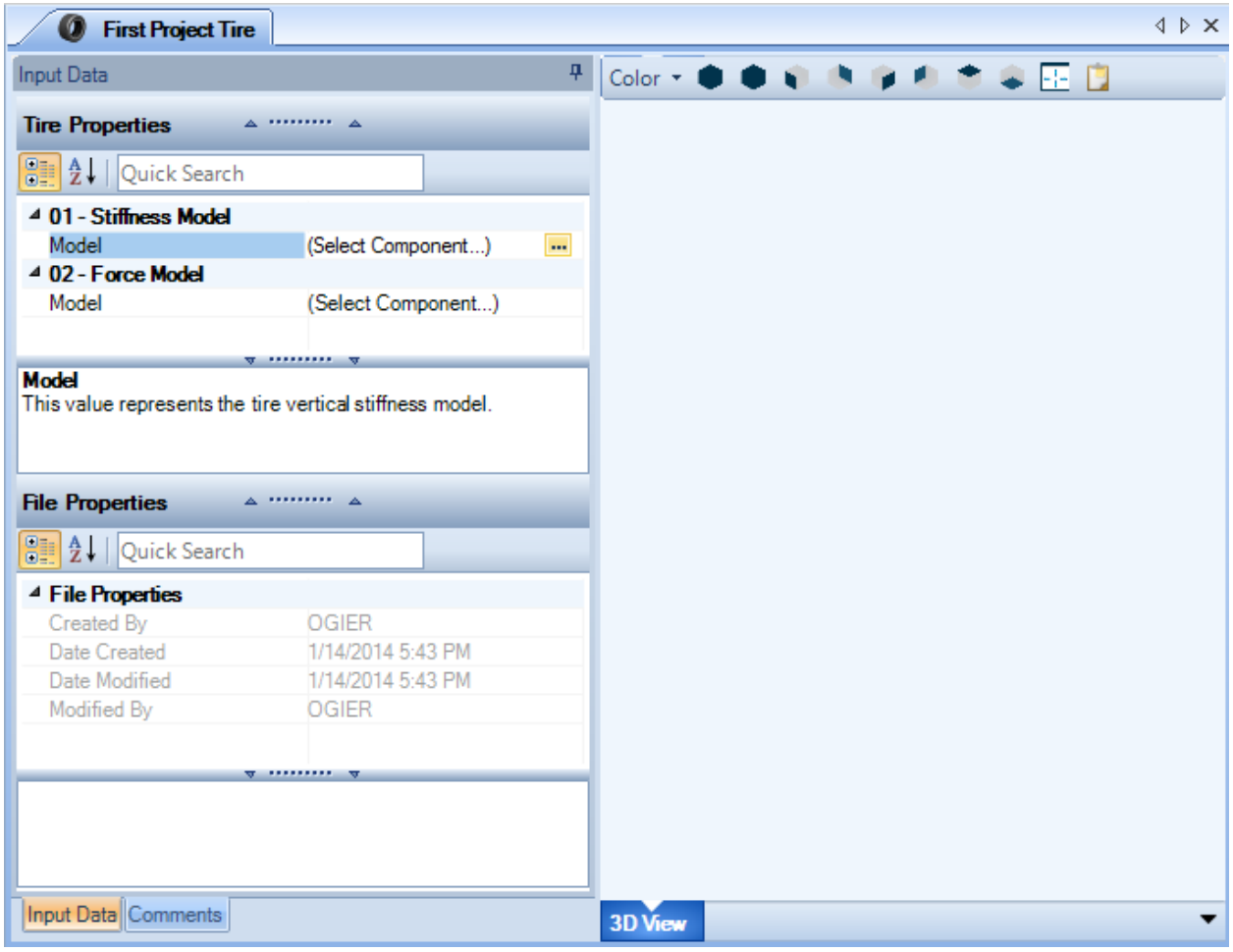
Tutorial 20% Done

This is a tire assembly that is composed of a previously defined tire stiffness model and a tire force model.

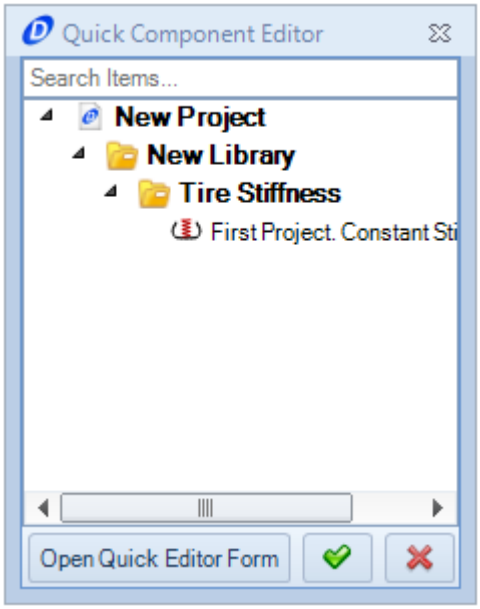
1. Click the **Add tire** button.

2. Click **New Tire.**

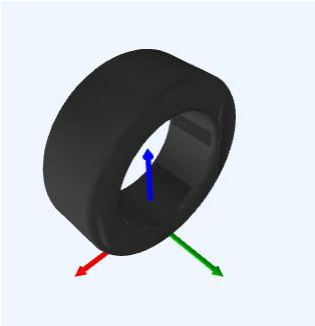




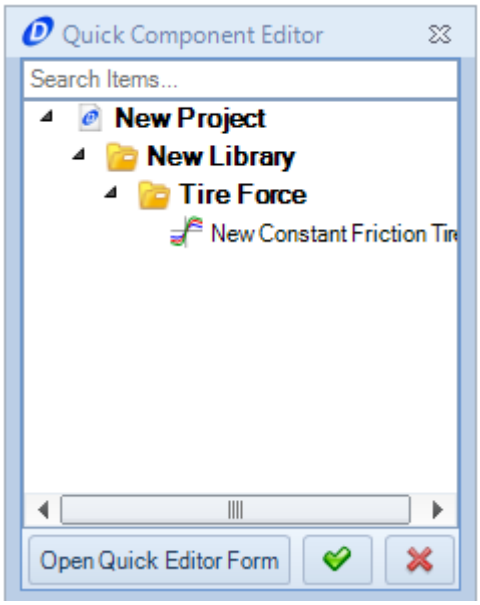
3. Click the ... button for the **Stiffness Model**.
4. In the **Quick Component Editor** select the previously created **Stiffness model**.



The tire appears in the **3D view.**



5. Click the ... button for the **Force Model**.
6. In the **Quick Component Editor** select the previously created **Force Model**.

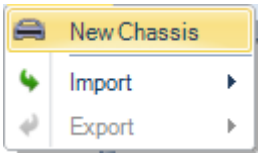


7. The **Tire** is now complete. Click **Save**.

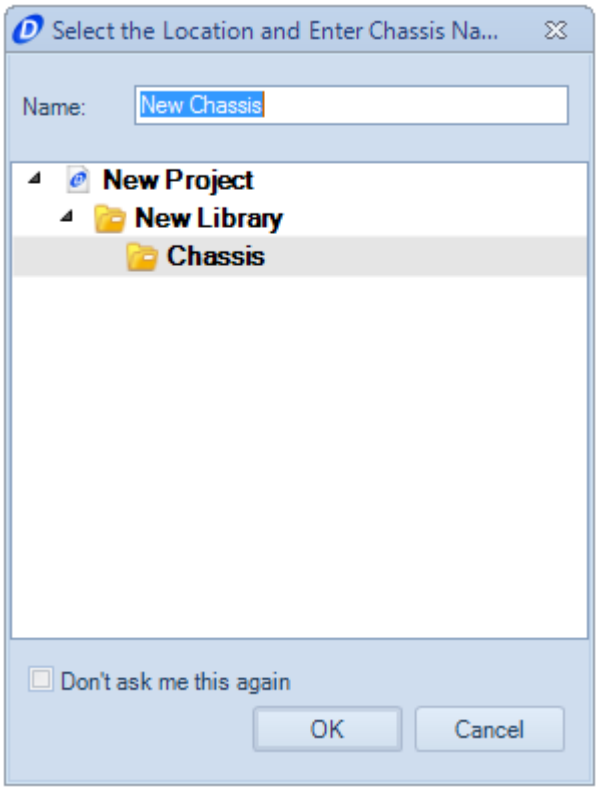
The chassis component is used to define the mass distribution of the vehicle. Either the distribution percentage or individual corner weight readings can be used to achieve this. A value for the center of gravity (CG) height is also required to fully define the vehicle chassis.

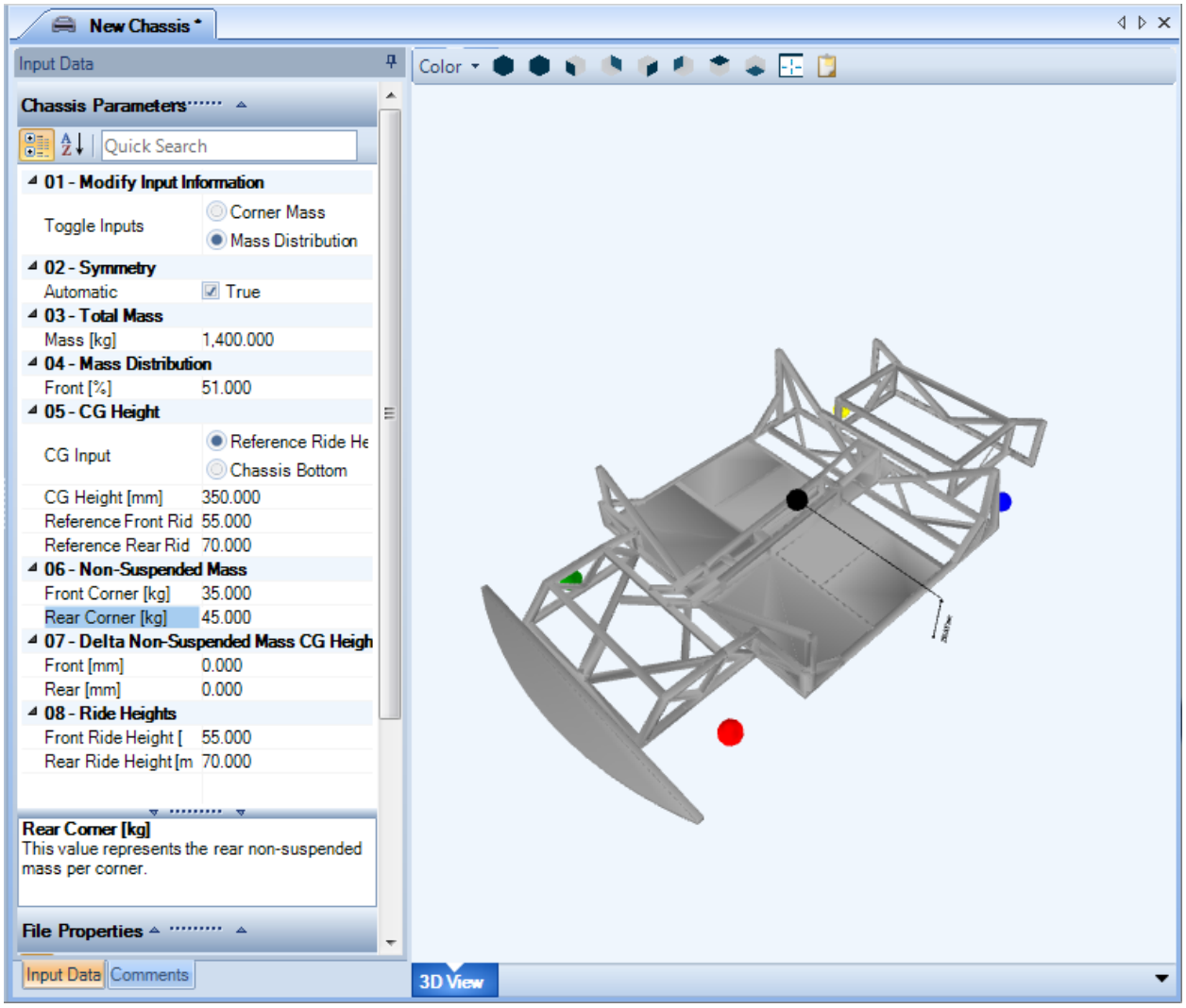
1. Click the **Add Chassis** button.

2. Select **New Chassis**.



3. Choose a name and click the **OK button.**





Notice that there are a few options for the type of inputs.

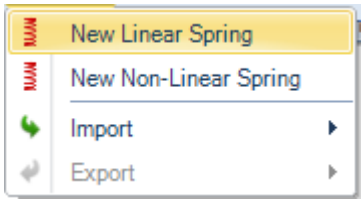
4. Choose **Mass Distribution** under "**Modify Input Information**" This allows us to input **Mass Distribution** as percentages. Ensure that the **Symmetry box** is checked. This assumes an equal left to right **Weight Distribution** for the vehicle.
5. Enter The values in the picture above

6. Under **CG Height** click **Reference Ride Heights**. This option means that when we enter the CG height value it will be given at a particular vehicle ride height. We determined our CG height of 350mm while the vehicle was at a static ride height of 55mm front and 70mm rear.

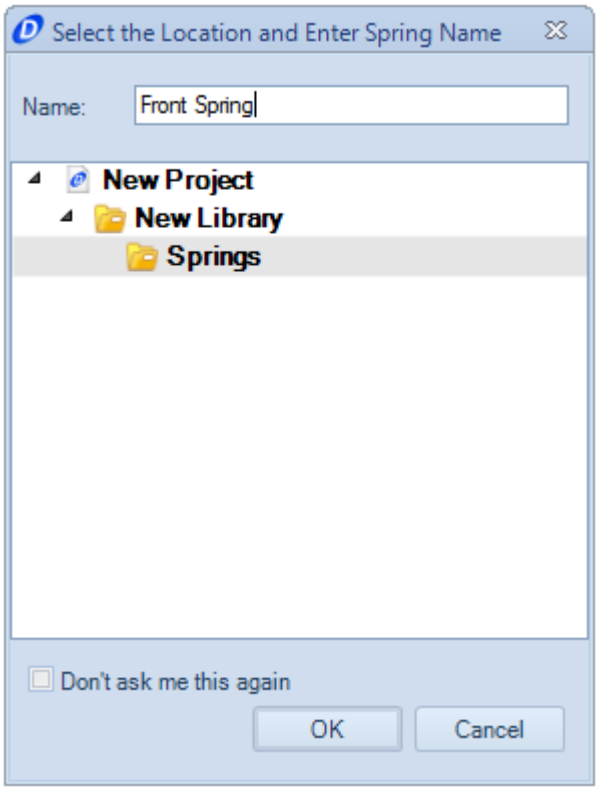
The vehicle springing is necessary to allow the suspension to operate. Some knowledge of this mechanism is required to determine how much, and in what way the suspension will move when inputs are applied in the simulation.

1. Click the **Add Spring** button.

2. Select **New Linear Spring**.
   This type of spring assumes a constant spring rate across the defined operating range.

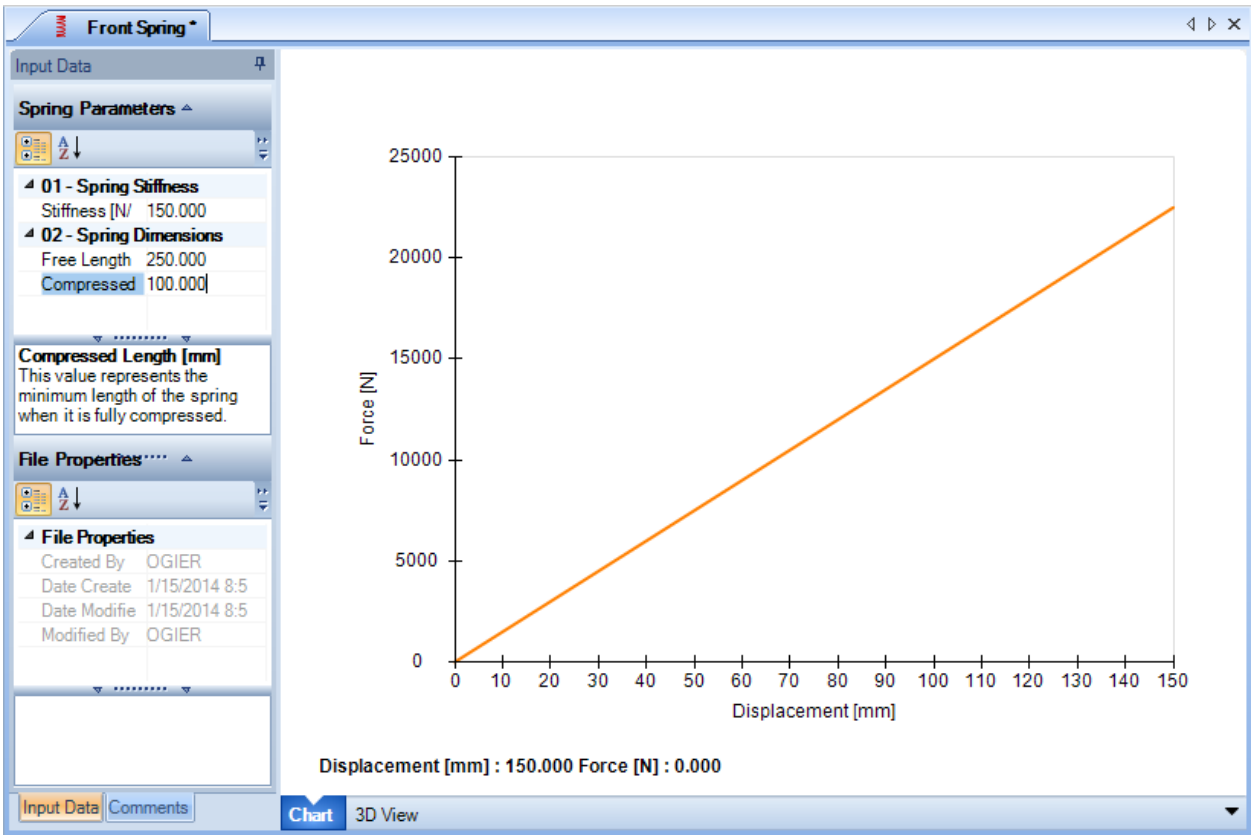


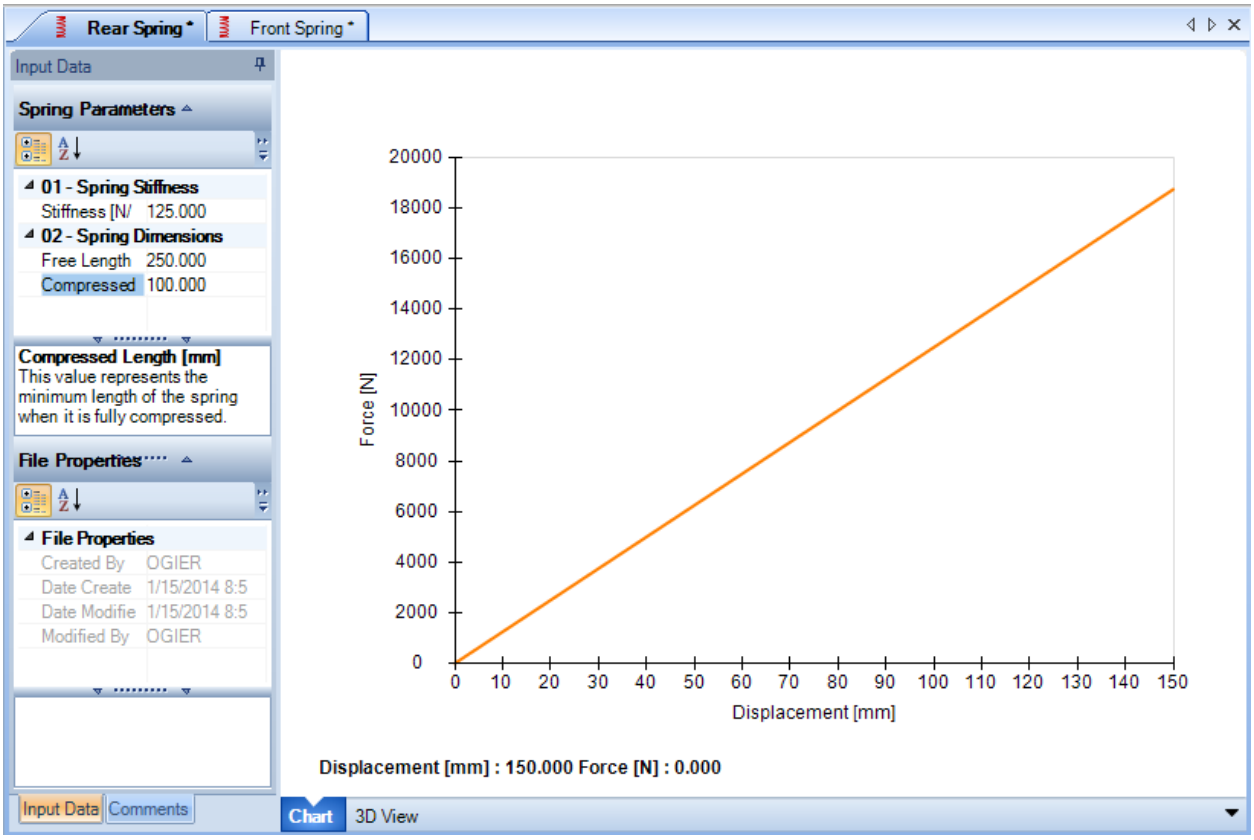
3. Enter the name as "*Front Spring*".
4. Press the **OK** button.
5. Repeat to make "*Rear Spring*".



6. Enter the values found on the next page.

At the bottom of the **Document Manager** you will see tabs for **Chart** and **3D View**. If you click **Chart** you will see a force vs. displacement curve.


Front Spring *
Input Data
Spring Parameters
01 - Spring Stiffness
Stiffness [N/ 150.000
02 - Spring Dimensions
Free Length 250.000
Compressed 100.000
Compressed Length [mm]
This value represents the minimum length of the spring when it is fully compressed.
File Properties
File Properties
Created By OGIER
Date Create 1/15/2014 8:5
Date Modifie 1/15/2014 8:5
Modified By OGIER
Input Data
Comments
Force [N]
Displacement [mm]
Displacement [mm] : 150.000 Force [N] : 0.000
Chart
3D View

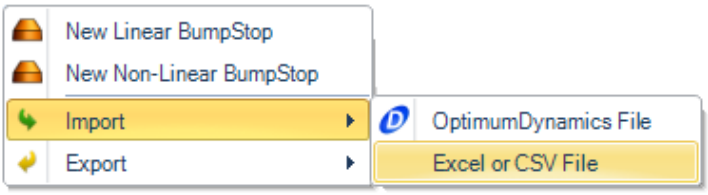

Rear Spring *
Front Spring *
Input Data
Spring Parameters
01 - Spring Stiffness
Stiffness [N/ 125.000
02 - Spring Dimensions
Free Length 250.000
Compressed 100.000
Compressed Length [mm]
This value represents the minimum length of the spring when it is fully compressed.
File Properties
File Properties
Created By OGIER
Date Create 1/15/2014 8:5
Date Modifie 1/15/2014 8:5
Modified By OGIER
Input Data
Comments
Force [N]
Displacement [mm]
Displacement [mm] : 150.000 Force [N] : 0.000
Chart
3D View

Bump stops are a common component seen on dampers. They are used to limit the maximum amount of suspension movement by increasing the effective spring rate when engaged.

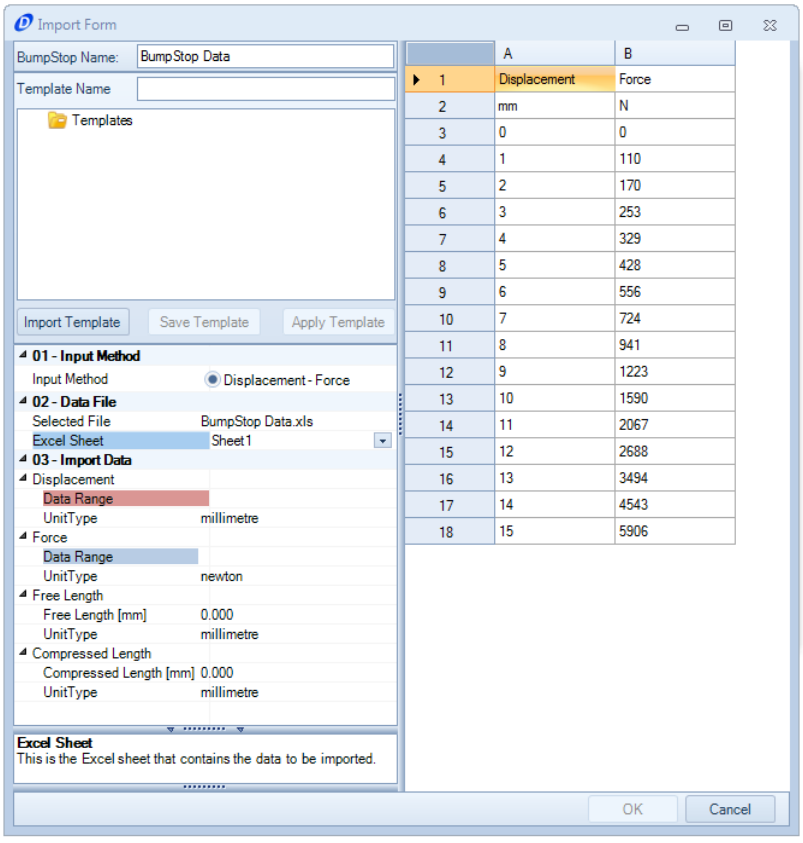
This section will go through importing data to create a bump stop. The same method can be used to import spring and ARB data.

1. Click the **Add Bump Stop** button.

2. Select **Import.**
3. Select **Excel or CSV File.**



4. Go to the OptimumDynamics Tutorial files
5. Change the file type to Excel 97-2003 Files
6. Select ***BumpStop Data.xls.***
7. The **Import Form** will appear.



8. In the **BumpStop Name** box you can rename the file if you choose.

9. Press the ... button for **Data Range** under **Displacement**
   The **Select Range** box will appear.

10. Press the **A** header of the first **column**.
    Every number in **Column A** will be selected.

11. Press the button.
    The Displacement Data Range is now selected.

12. Press the ... button for Data Range under Force.

13. Click Cell B3.

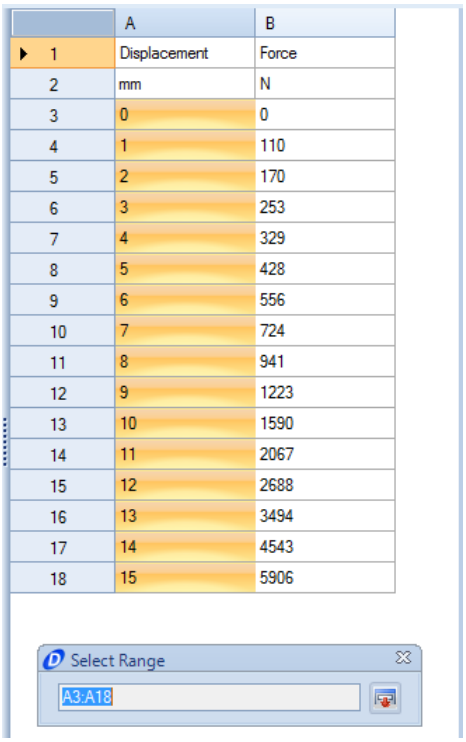
14. Press Ctrl+Shift+Down arrow
    Every cell from B3 to the end of the column is now selected.

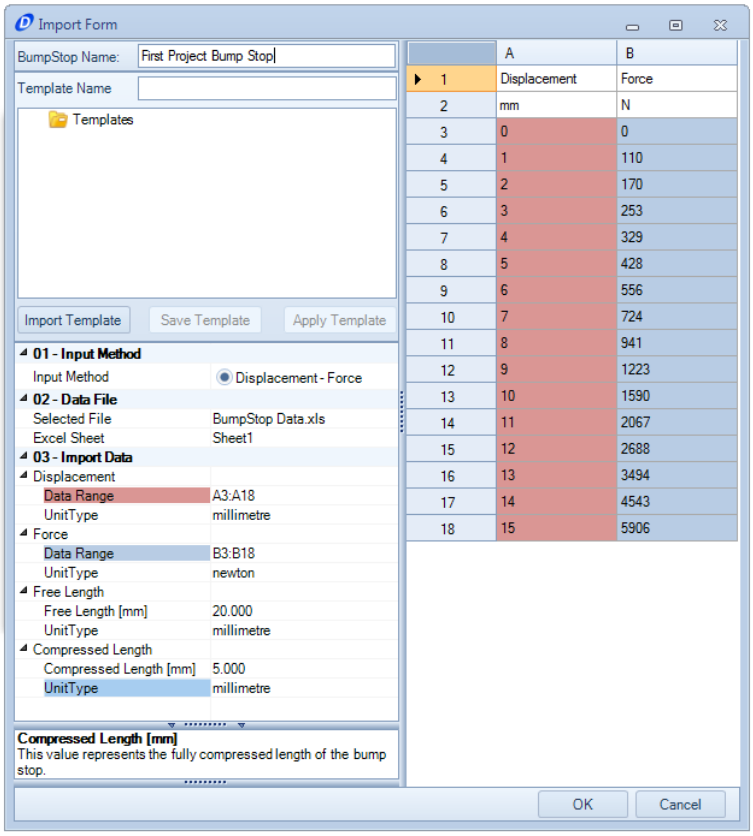
15. Enter **20** mm in the **Free Length** box.

16. Enter **5** mm in the **Compressed Length** box.

17. Press **OK.**

    The **Document Manager** will show the Force vs. Displacement curve of the imported bump stop.

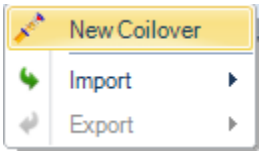




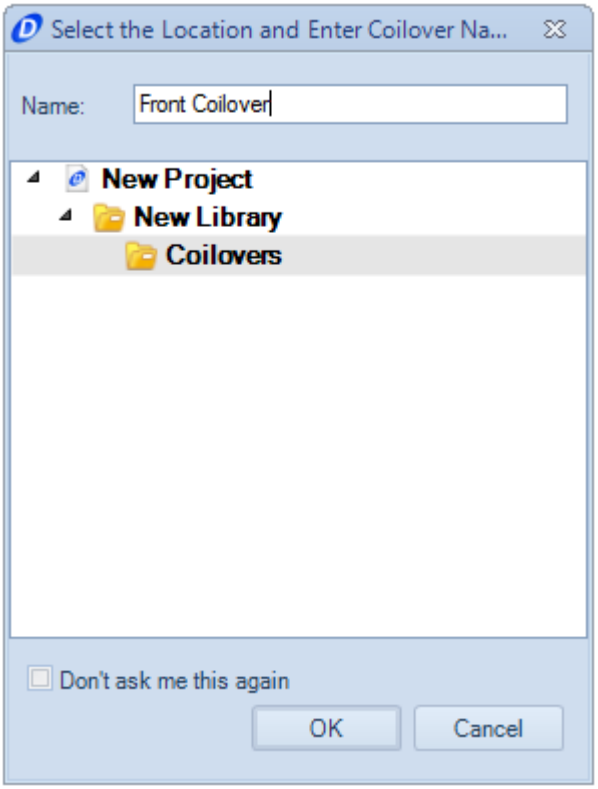
This is an assembly of a previously defined spring and/ or a bump stop model. In addition to defining the spring and/ or bump stop components you will also need to define the corresponding gap or preload.

1. Press the **Add Coilover** button.

2. Select **New Coilover.**

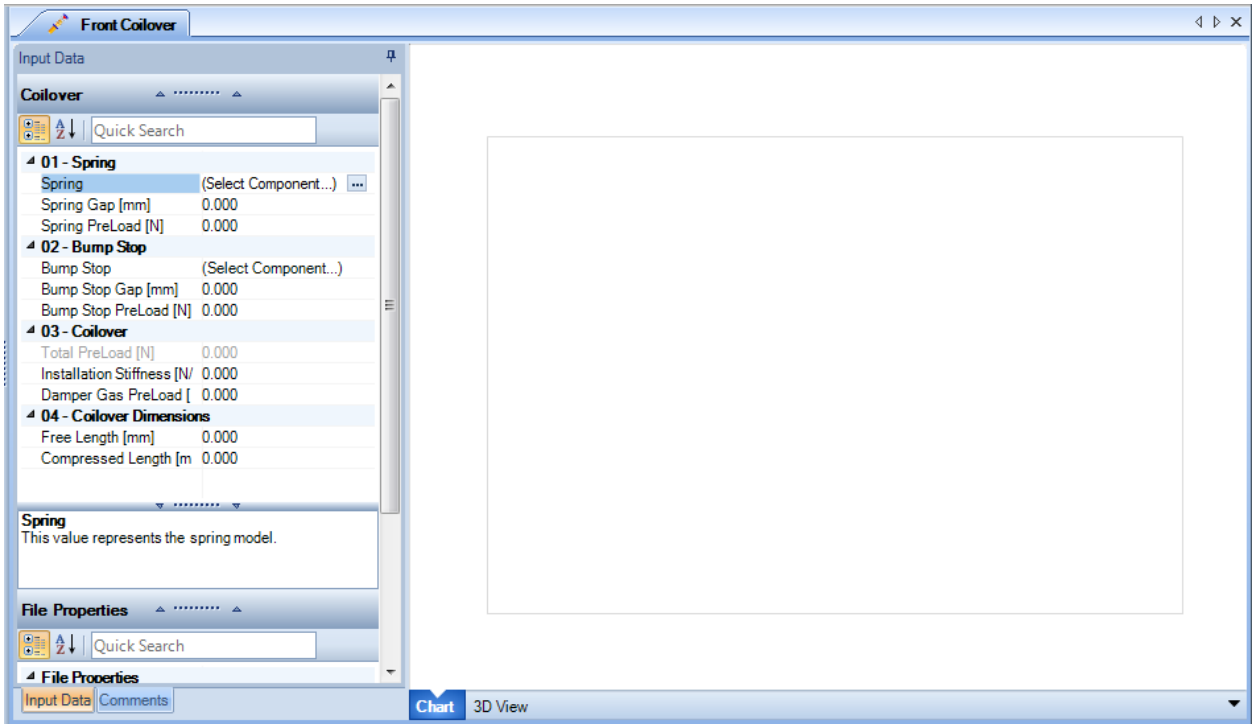


3. Enter "*Front Coilover*" as the name.
4. Press the **OK button**.



5. Repeat to make the "*Rear Coilover*".

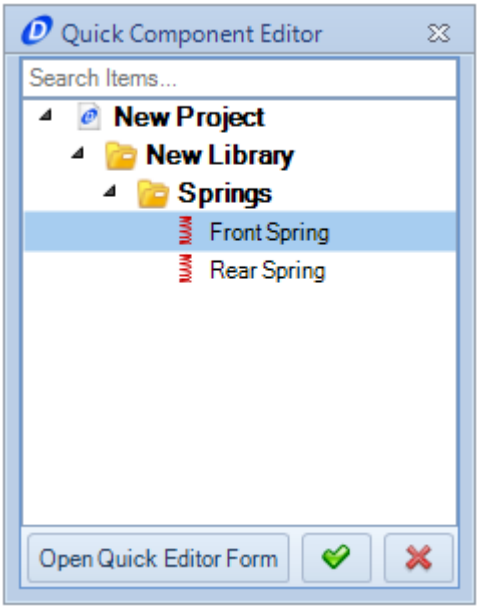
Like the **Tire**, the **Coilover** is an assembly.



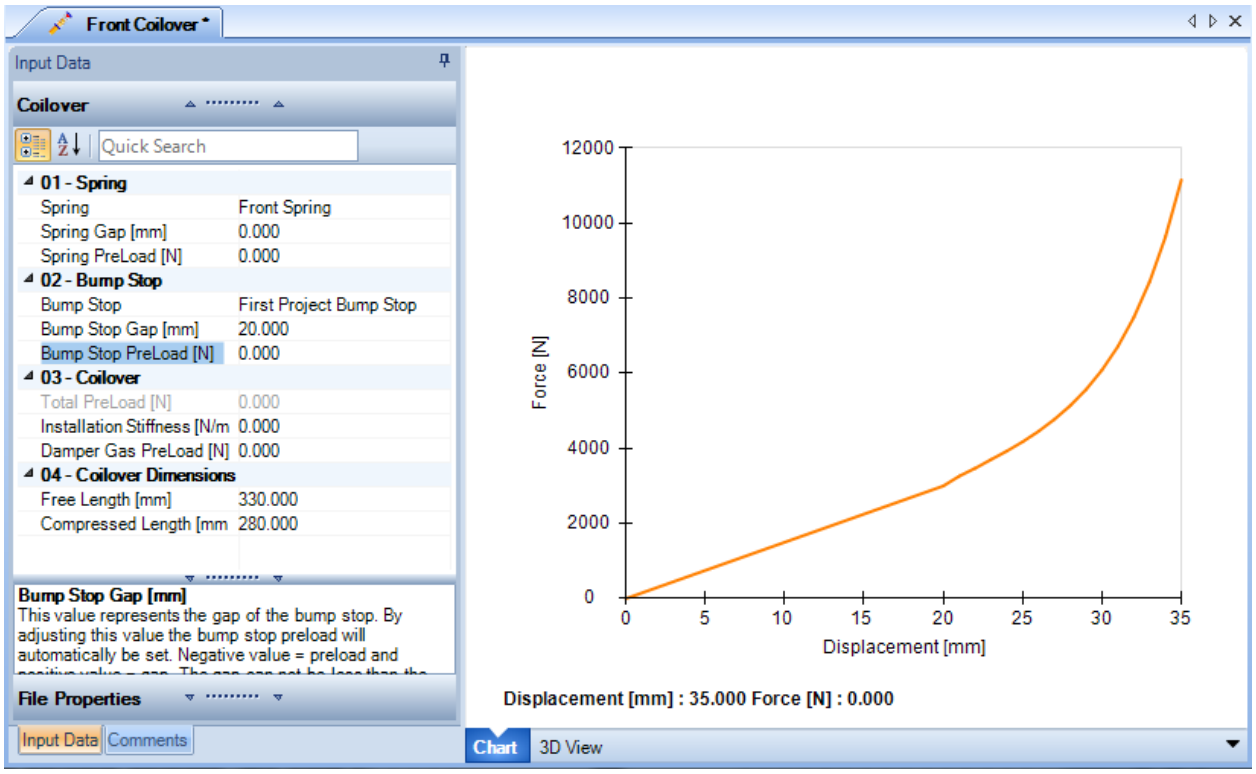
This is the **Document Manager** of the **Coilover**.

Before selecting the components change the **Free Length** to **330 mm**

6. Now select the Front Spring



7. Next select the Bump Stop



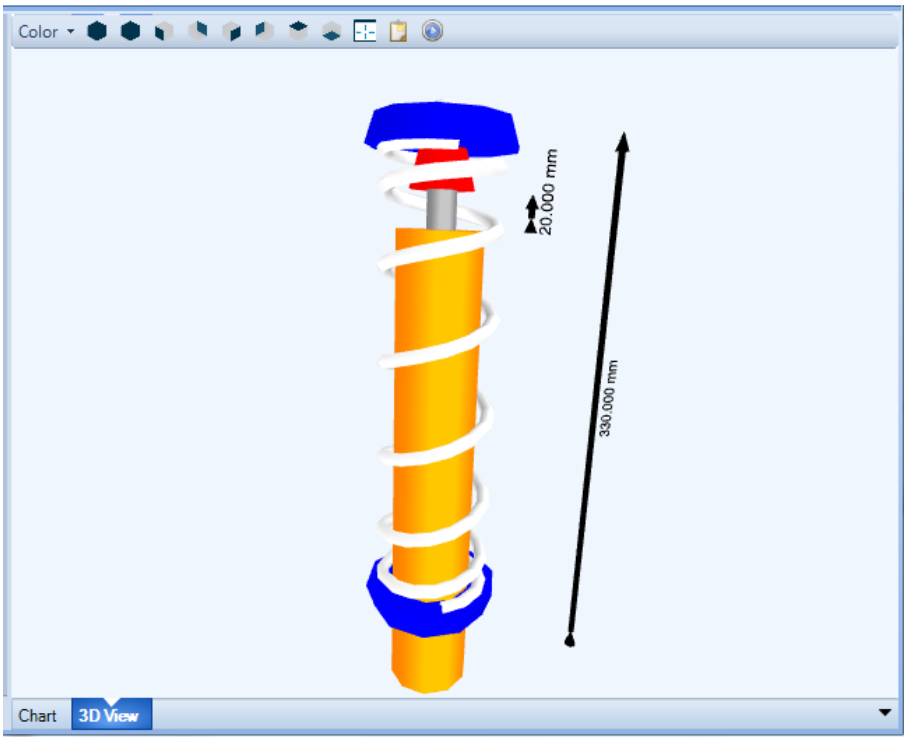
8. Enter the inputs seen in the above picture.

   Have a look at the force vs. displacement curve and notice how the curve changes at 20mm of displacement. This is the point at which the bump stop becomes engaged. This point is determined by the bump stop gap of 20mm that we set in the input.

   Another way you can modify components is through the **3D view**. We will change the **Bump Stop Gap** with this method.

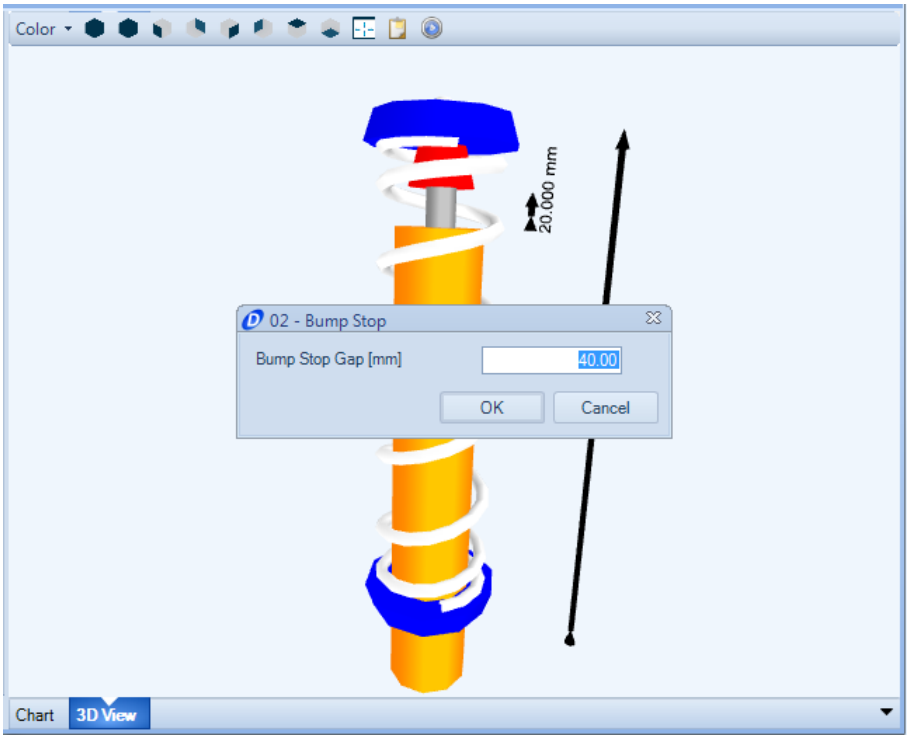
9. Click the **3D View** tab at the bottom of the **Document Manager.**

10. Double Click on the 20mm dimension seen in the image. This represents the **Bump Stop Gap** of the coilover.

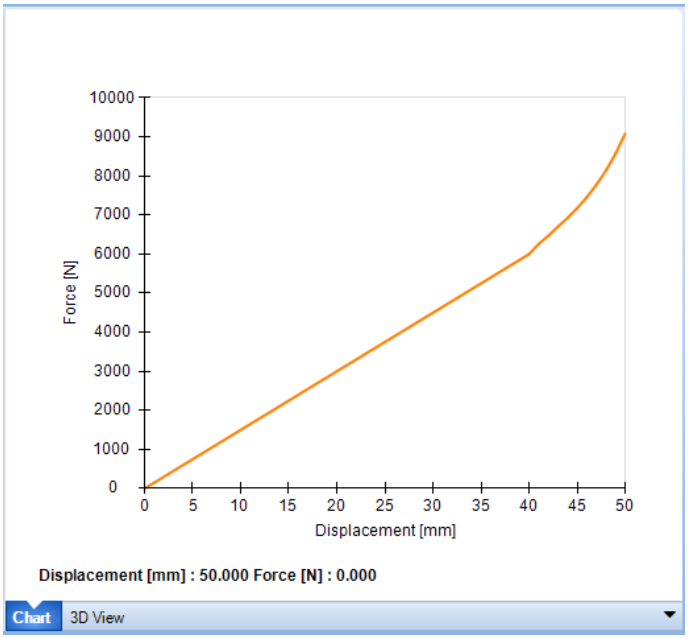


The **Bump Stop Gap** edit dialog will appear.

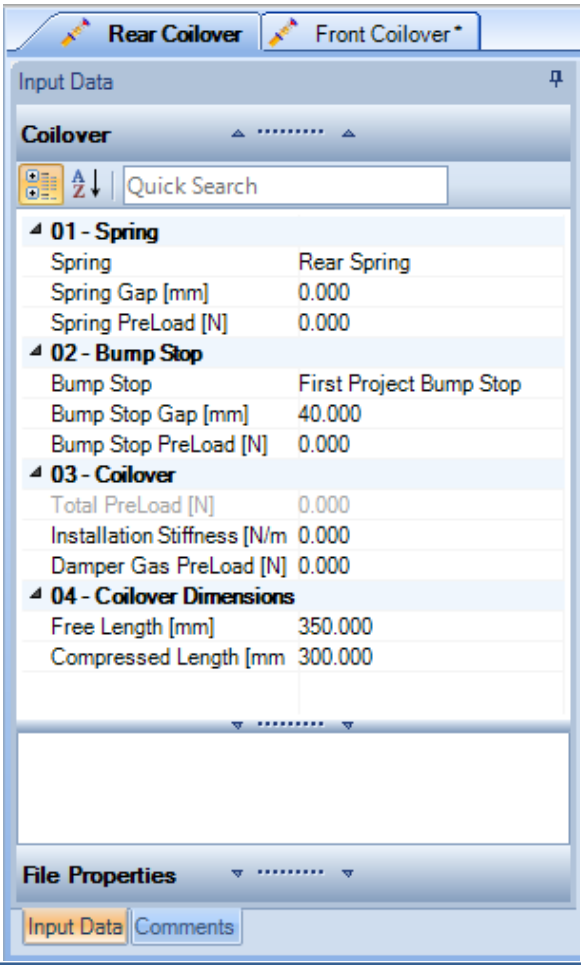
11. Enter 40 and press the **OK button**



Go back to the chart tab and notice that the Force vs Displacement curve now changes at 40mm.

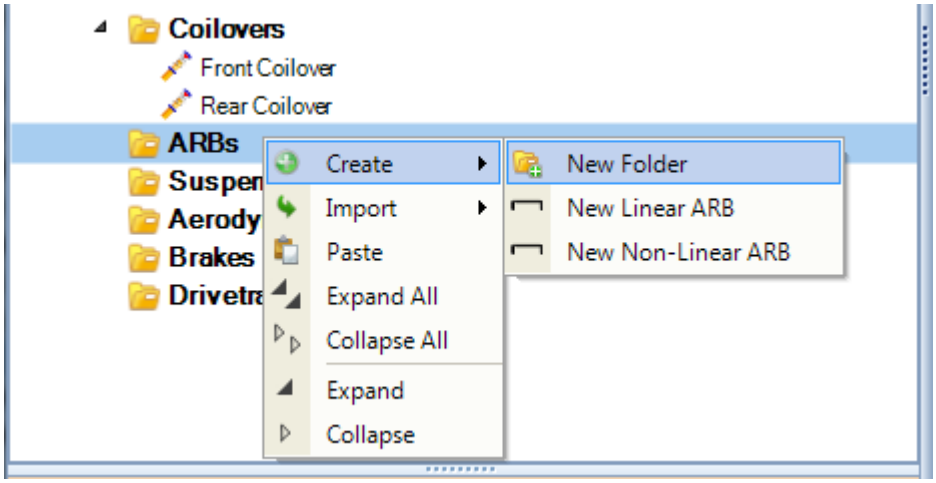


12. For the Rear Coilover enter the following inputs.

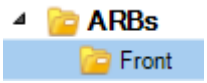


We will be creating multiple anti-roll bar components, let's try and keep things organized. We can achieve this by grouping common components into folders.

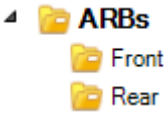
1. In the **Project Tree** right click the **ARBs Folder**, go to **Create** select **New Folder.**



2. Name the **folder** *Front.* This **folder** will contain all of the front ARB models.



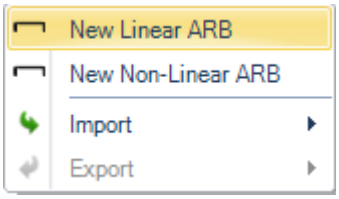
3. Make a second **folder** for the Rear ARBs.



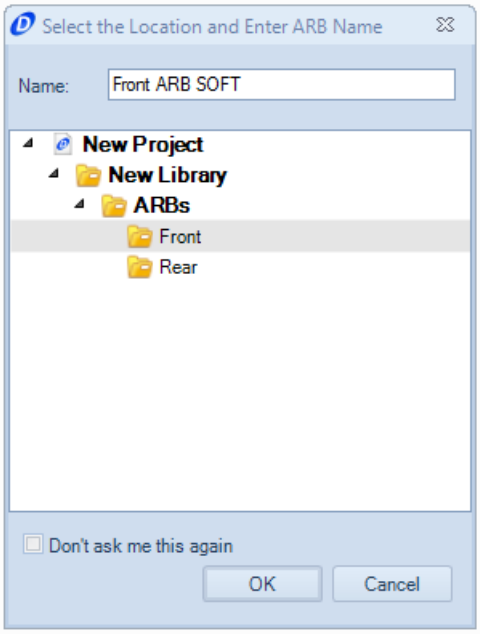
Now let's create the ARB components.
The anti-roll bar on the vehicle only provides suspension stiffness during vehicle roll and has no effect during heave motion.

4. Press the **New ARB** button.

5. Select **New Linear ARB.**
A linear ARB is assumed to have a constant spring rate over its range of travel.



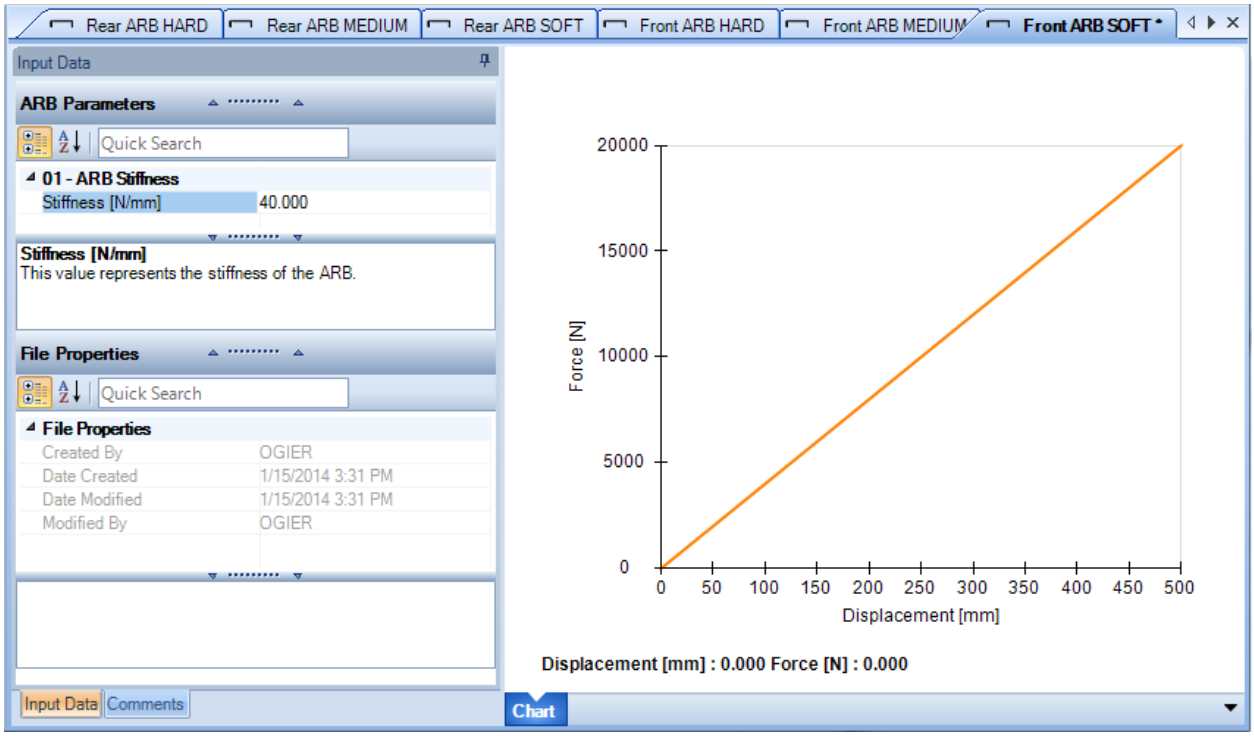
6. Enter "*Front ARB SOFT*".
7. Select the Folder Named *'Front'* that we just created



8. Press the **OK button**.

9. Create two more **ARB**s for the front
    a. Name one of these "*Front ARB MEDIUM*"
    b. Name the other one "*Front ARB HARD*"

10. Similarly create a soft, medium, and hard **ARB** for the rear, be sure to save them in the Rear folder that we created earlier.



11. For "Front ARB SOFT", enter 40 in the **Stiffness** field

12. Fill out the remaining ARB Stiffness values using the table below. Ensure you enter the values in the correct ARB model.

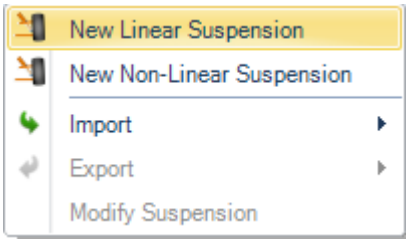
Tutorial 1 ARB Stiffness (N/mm)			
	Soft	Medium	Hard
Front	40	60	80
Rear	58	85	115

We now have a **library** of ARB choices that we will be using later for creating vehicle setups.

The definition of a suspension is important as it describes the layout and motion of the vehicle.

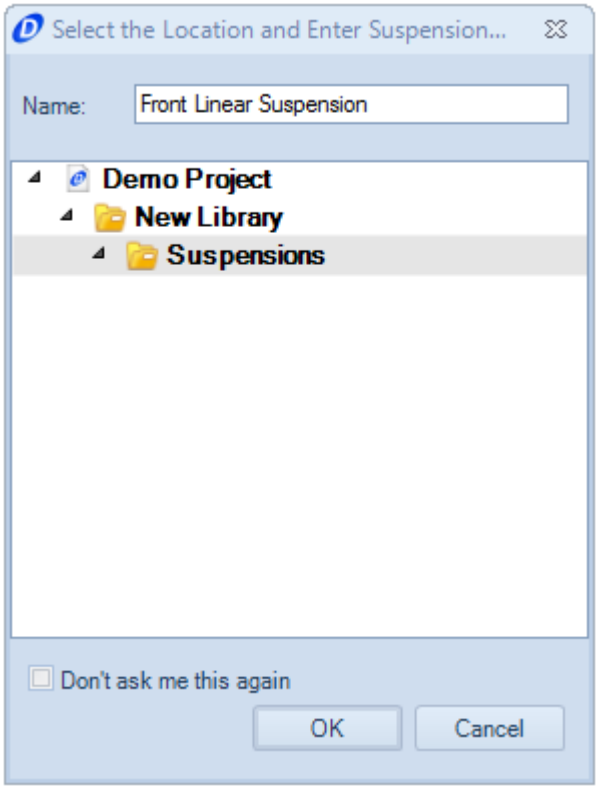
1. Press the **Add Suspension** button.

Select **New Linear Suspension.**

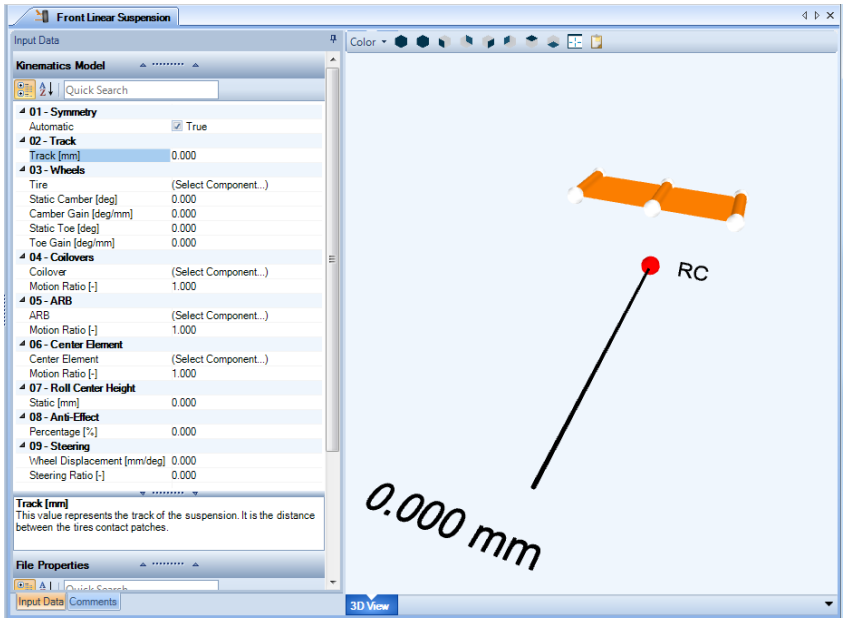


When defining a linear model the geometry of the suspension is not known and is instead defined using linear models to represent camber gain, toe gain and motion ratio. In addition to this you will need to define the roll center heights and anti-effects.

2. Name it '*Front Linear Suspension*.'
3. Press the **OK** button.



4. Create another **Linear Suspension** for the rear.



Like the **Coilover**, the **suspension** is an assembly of components and inputs.

Front Linear Suspension

Input Data

Kinematics Model

Quick Search

01 - Symmetry	
Automatic	True
02 - Track	
Track [mm]	1,600.000
03 - Wheels	
Tire	First Project Tire
Static Camber [deg]	-2.000
Camber Gain [deg/mm]	0.040
Static Toe [deg]	0.200
Toe Gain [deg/mm]	0.040
04 - Coilovers	
Coilover	Front Coilover
Motion Ratio [-]	1.200
05 - ARB	
ARB	Front ARB SOFT
Motion Ratio [-]	1.010
06 - Center Element	
Center Element	(Select Component...)
Motion Ratio [-]	1.000
07 - Roll Center Height	
Static [mm]	50.000
08 - Anti-Effect	
Percentage [%]	10.000
09 - Steering	
Wheel Displacement [mm/deg]	0.500
Steering Ratio [-]	25.000

Rear Linear Suspension

Input Data

Kinematics Model

Quick Search

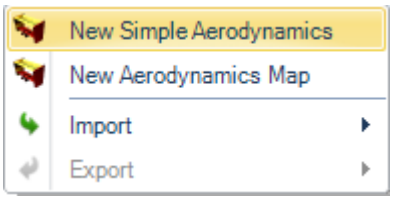
01 - Symmetry	
Automatic	True
02 - Track	
Track [mm]	1,550.000
03 - Wheels	
Tire	First Project Tire
Static Camber [deg]	-2.000
Camber Gain [deg/mm]	0.040
Static Toe [deg]	0.200
Toe Gain [deg/mm]	-0.200
04 - Coilovers	
Coilover	Rear Coilover
Motion Ratio [-]	1.200
05 - ARB	
ARB	Rear ARB SOFT
Motion Ratio [-]	1.200
06 - Center Element	
Center Element	(Select Component...)
Motion Ratio [-]	1.000
07 - Roll Center Height	
Static [mm]	80.000
08 - Anti-Effect	
Percentage [%]	10.000
09 - Steering	
Wheel Displacement [mm/deg]	0.000
Steering Ratio [-]	0.000

Enter the inputs for the front and rear suspensions using the values from the corresponding picture above.

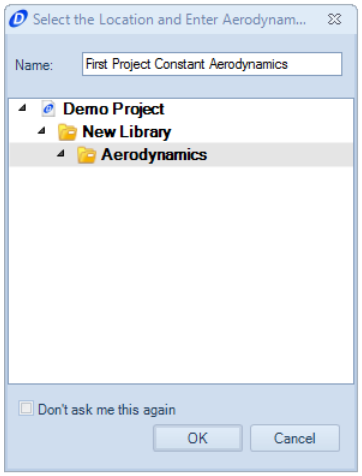
The option to define the vehicle aerodynamics is possible in OptimumDynamics. This is important for most vehicles as it influences the top speed and the overall vehicle performance.

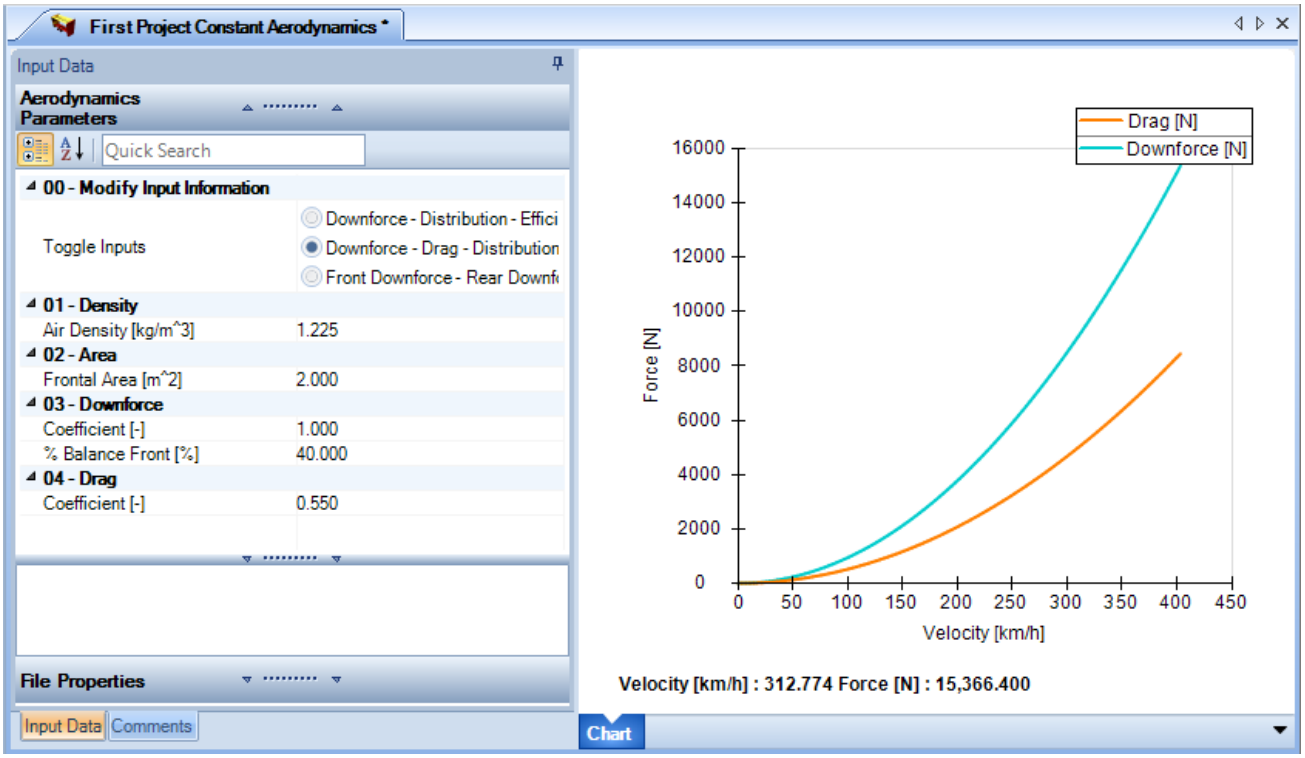
1. Press the **New Aerodynamics** button.

2. Select **New Simple Aerodynamics**.



3. Enter a name.
4. Press the OK **button**.





5. Under **Modify Input Information** select **Downforce – Drag – Distribution.**

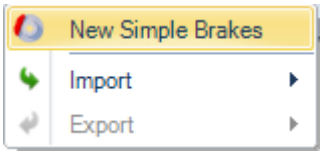
6. Enter the values seen in the above picture.

Creating Brakes

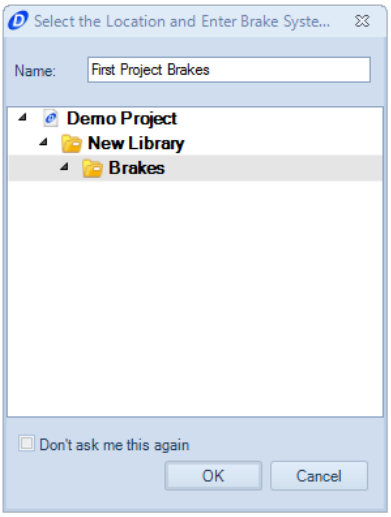
The braking system of the vehicle can be defined simply by the location of the brakes and the distribution of braking force front to rear. The braking distribution is assumed to be constant in this model and does not depend on the hydraulic layout of the actual braking system.

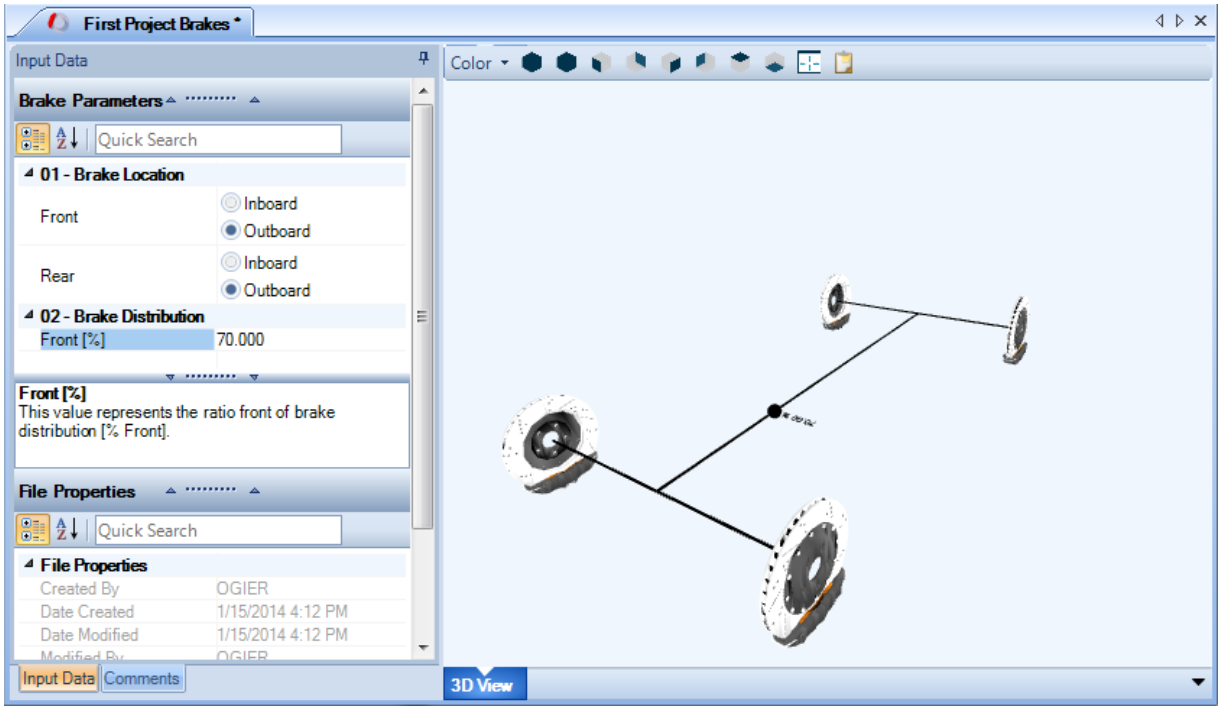
1. Press the **Add Brakes** button.

2. Select **New Simple Brakes**.



3. Enter a name and press the **OK** button.





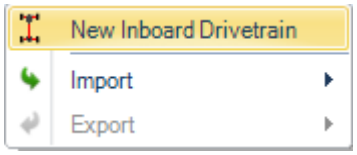
4. Select **Outboard** for the Front and Rear under **Brake Location**.

5. Enter the value seen in the picture for **Brake Distribution**.

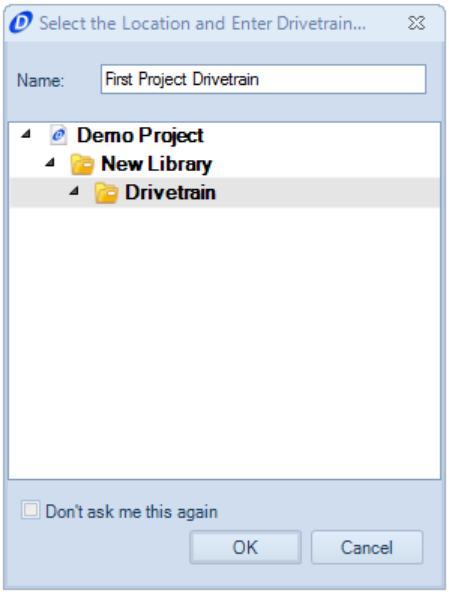
This component describes the drive layout of the vehicle.

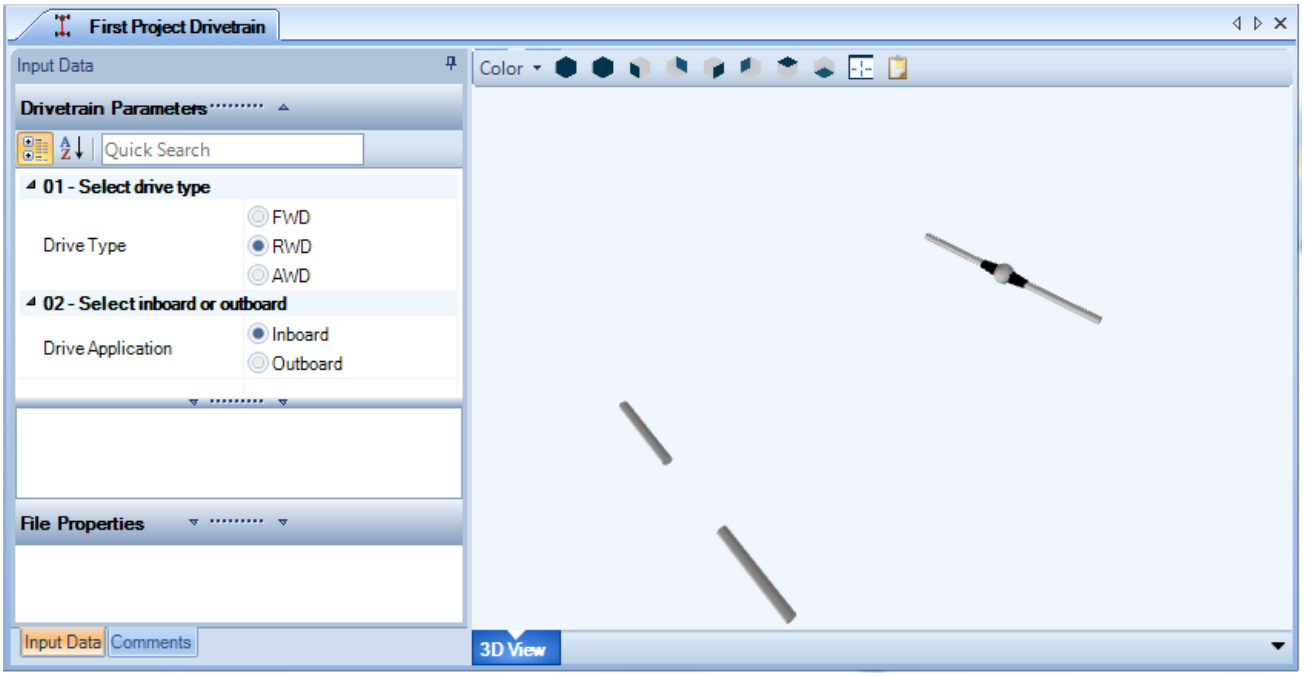
1. Press the **Add Drivetrain** button.

2. Select **New Inboard Drivetrain.**



3. Enter a name and press the **OK** button.



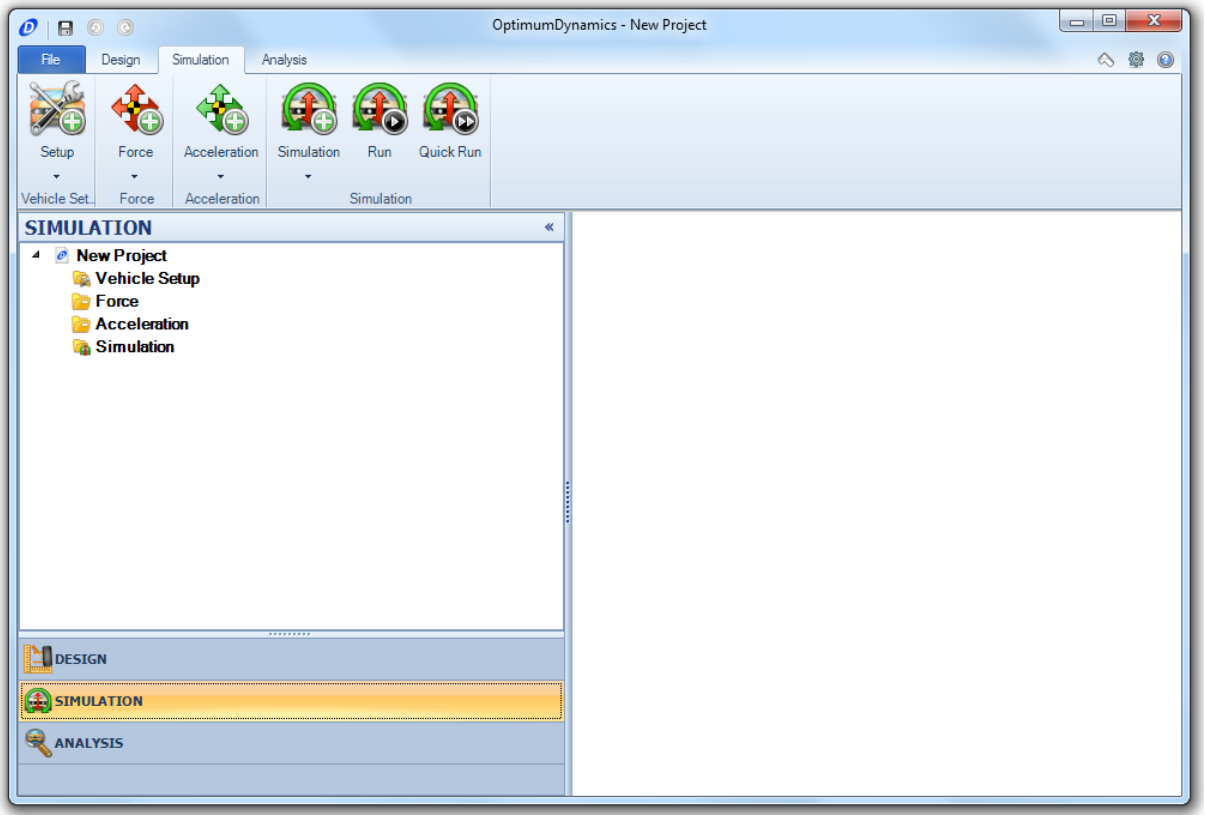


4. Here you select the **Drive Type** and **Drive Application** of the **drivetrain**. Select the options shown in the picture.

The vehicle setup allows you to combine the different components and assemblies that were previously defined into a single vehicle setup.

Vehicle setups are defined from the components and assemblies in the project library. It is important to note that the components and assemblies defined in the library are not affected by changes in the components in the vehicle setup or vice versa. This is because the vehicle setups are not linked to actual components in the library; they are copied once on creation only.

1. In the **Ribbon Control** select the **Simulation** tab
   Alternatively you can press the **Simulation** button in the **Project Tree**.



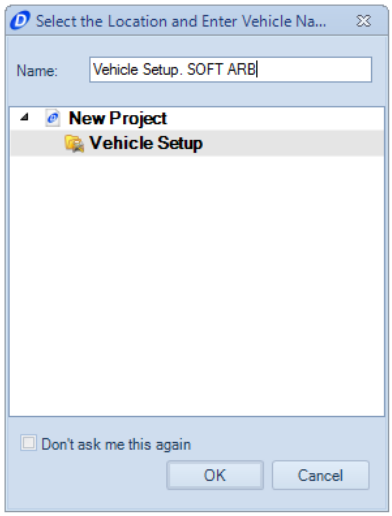
You will see a new **Ribbon Control** for the **Simulation** GUI. Much like in **Design**, the **Simulation Ribbon Control** is designed to work from left to right.

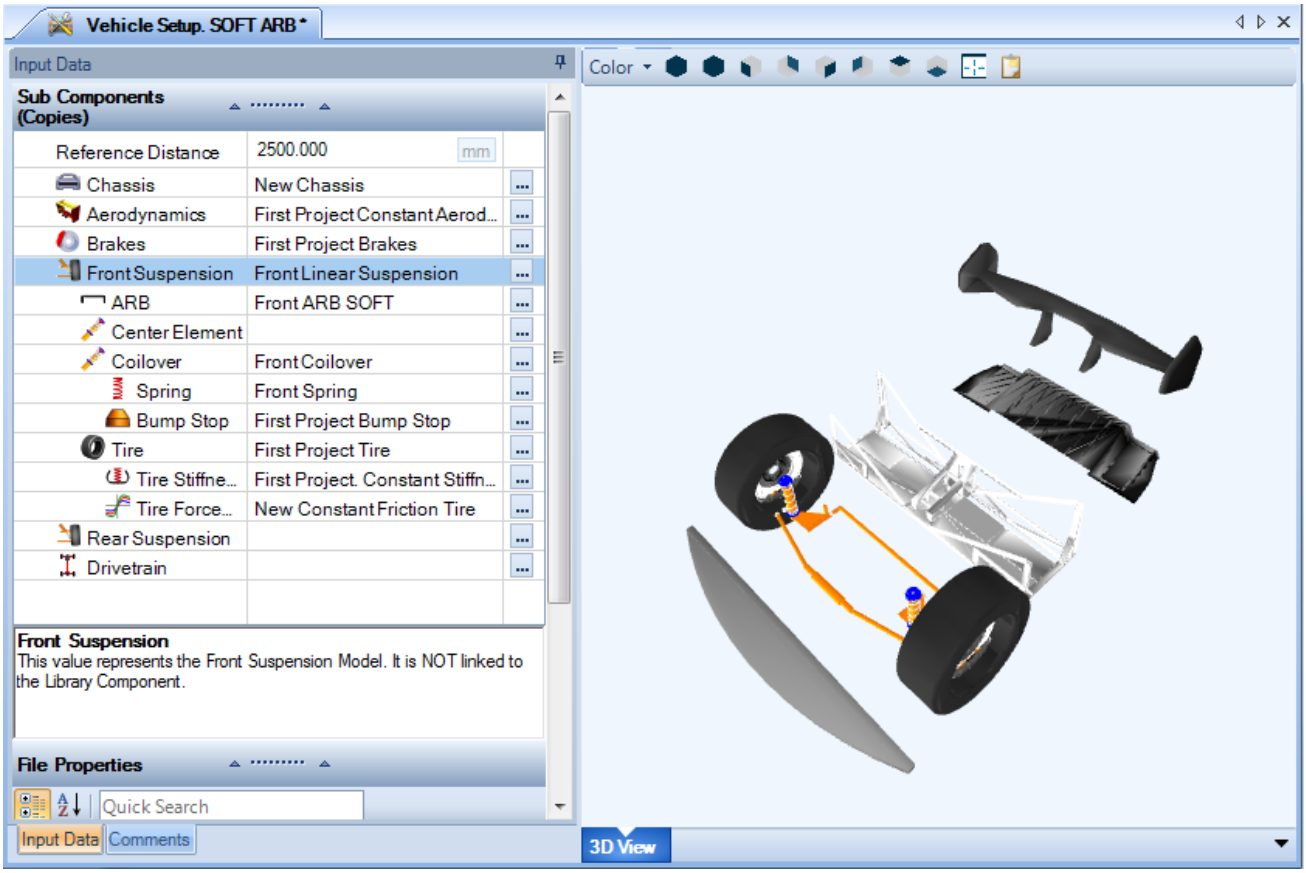
For this tutorial we are only making a **Vehicle Setup**. We will be utilizing the vehicle setups that we create in *Tutorial 2*.

2. Press the **New Vehicle Setup** button.

3. Enter "*Vehicle Setup. SOFT ARB*" for the name.

4. Press **OK.**





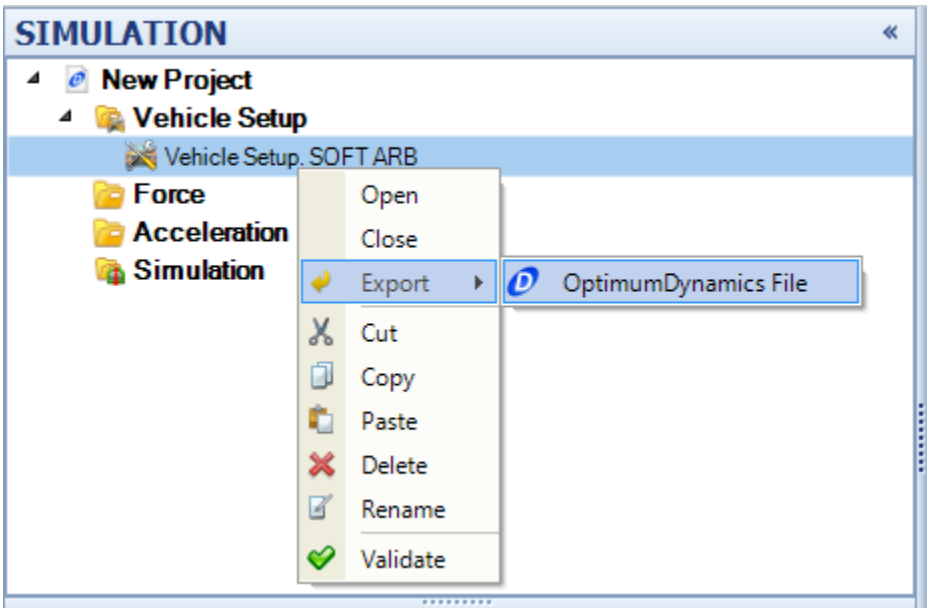
5. Enter the **Reference Distance** seen in the picture above
   For a linear suspension the reference distance is simply the vehicle wheelbase.

6. Start adding components
   Notice when the **Front Suspension** is added all of the suspension components are visible.

7. Continue down the **Vehicle Setup** to select the remaining components.
   NOTE: An **aerodynamics** model is not needed to run a **simulation**.

   Your first **Vehicle Setup** is now made!
   Now let's make two more **Vehicle Setups**, one for each type of **ARB** we made for the **Design Library.**

1. Right click the **Vehicle Setup** you just created and **export** it as an **OptimumDynamics File.**



2. Choose a destination to save the file, and name it "*Vehicle Setup. MEDIUM ARB*".

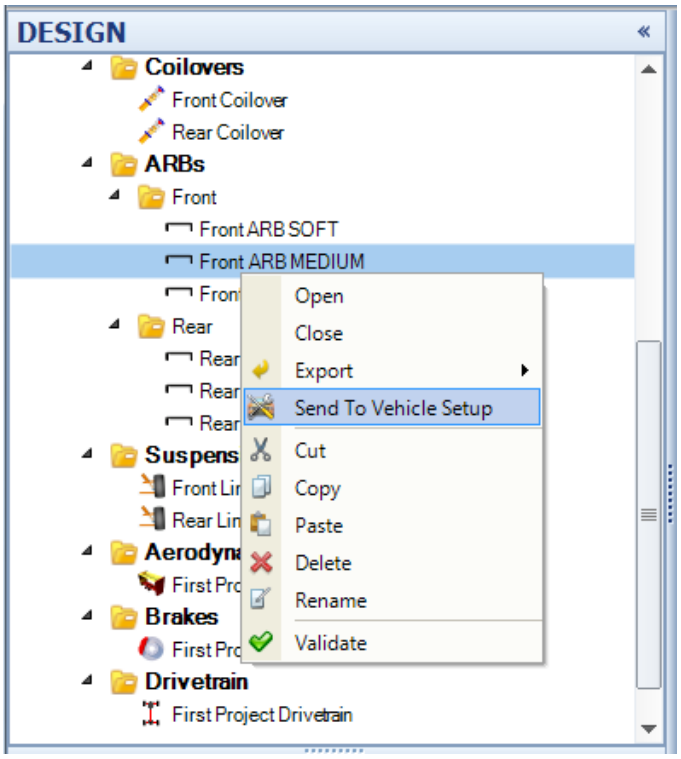
1. Press the **Add Vehicle Setup** Button.

2. Select **Import**.
3. Select **OptimumDynamics File.**
4. Select the file you previously exported.

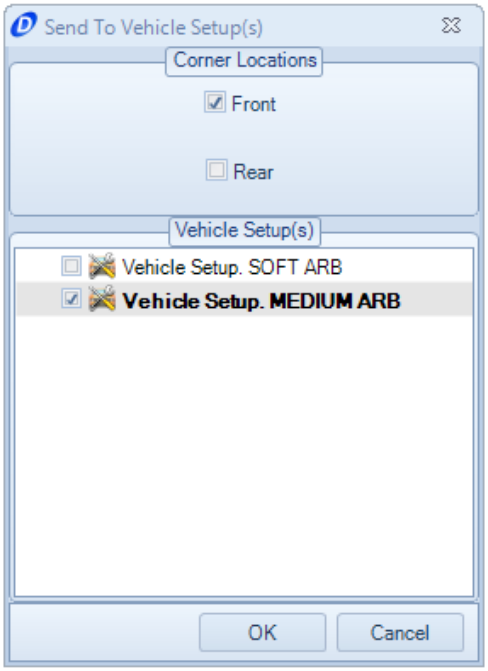
The **Vehicle Setup** you imported is now open in the **Document Manager.**
We named this **Vehicle Setup** "*Vehicle Setup. MEDIUM ARB*" so let's put the Medium ARB components in.

1. You can press the ... button in the **ARB** components section of the **Vehicle Setup** to select the MEDIUM ARB from the **library**.

   Alternatively you can **export** from the **library** to the **Vehicle Setup.**



2. Go back to the **Design** GUI.
3. Right click on Front ARB MEDIUM
4. Select **Send to Vehicle Setup**.

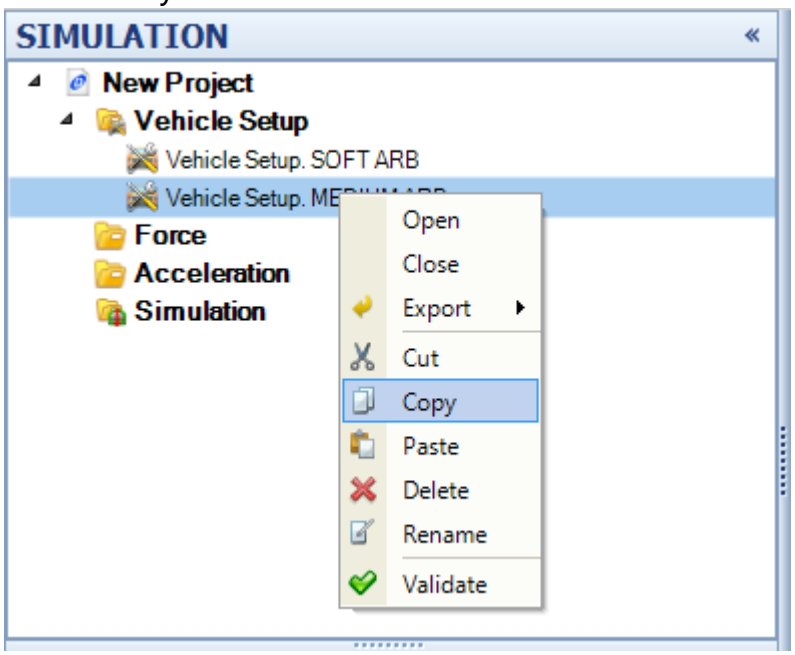


5. The **Send to Vehicle Setups** dialog will appear.
6. Select "Front" under **Corner Location**
7. Select "Vehicle Setup. MEDIUM ARB" under **Vehicle Setups.**

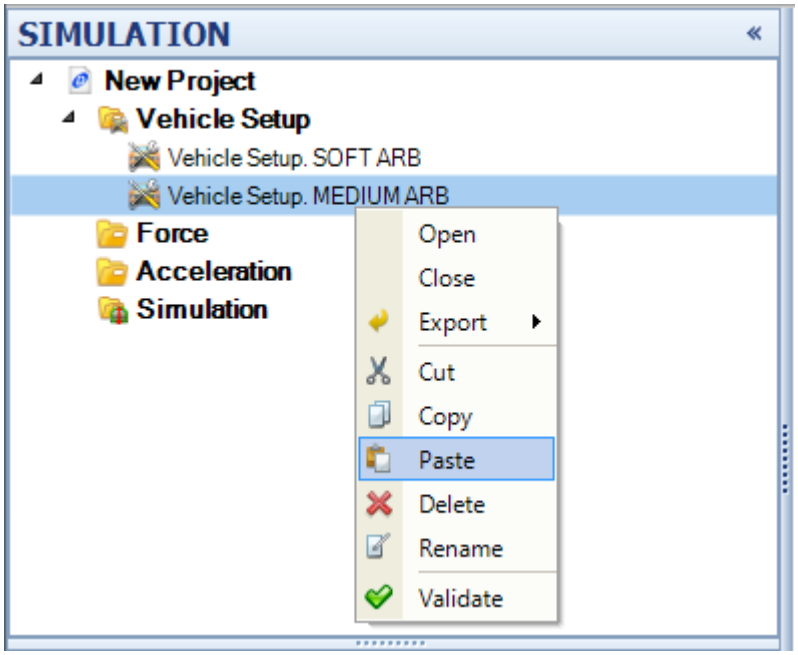
8. Do the same for Rear ARB MEDIUM, but be sure to select **Rear** as the location for it to be sent.

Another method of creating a **Vehicle Setup** is to **Copy-Paste** an existing **Vehicle Setup**

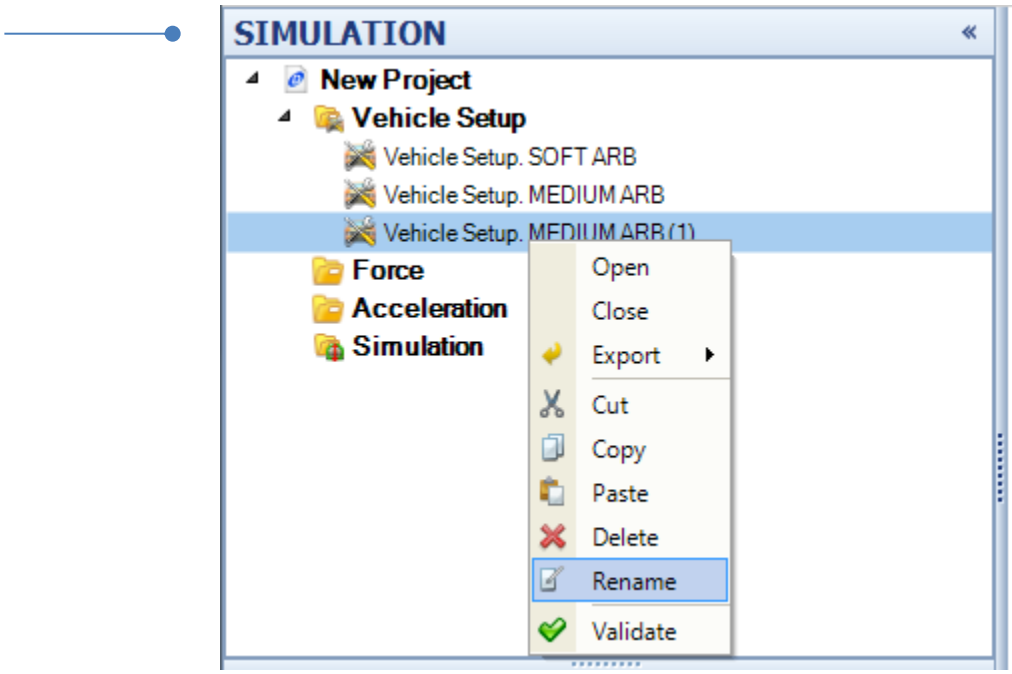
1. Right click a **Vehicle Setup** you have already made.
2. Select **Copy.**



3. Right click again.
4. Select **Paste.**



5. **Rename** the Vehicle Setup "*Vehicle Setup. HARD ARB*".



In the previous steps we learned how to add a component from the **library** to the **Vehicle Setup**.

6. Using the method of your choice, add the Hard ARB we created earlier into "*Vehicle Setup. HARD ARB*".

Tutorial 2 uses these three Vehicle Setups you have created.

7. Export the 3 vehicle setups you have created. "*Vehicle Setup. SOFT ARB", "Vehicle Setup. MEDIUM ARM",* and *"Vehicle Setup. HARD ARB"*.

Tutorial one is now complete!
Let's review what we have learned

Tutorial 1

- Ribbon Control
  - Flows left to right
- Components
  - How to create
  - How to make assemblies of components
- 3D view
  - How to edit components and assemblies
- Vehicle setups
  - How to create
  - How to edit
  - How to export
  - How to import

You are now ready to learn how to use your **Vehicle Setups** in a **Simulation**! Step by Step instructions can be found in **OptimumDynamics Tutorial 2**.

About OptimumG

OptimumG is an international vehicle dynamics consultant group that works with automotive companies and motorsports teams to enhance their understanding of vehicle dynamics through seminars, consulting and software development.

About OptimumDynamics

OptimumDynamics is the newest benchmark in computational vehicle dynamics analysis software. It is a versatile software tool that allows you to investigate the dynamic handling and performance characteristics of any vehicle.

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