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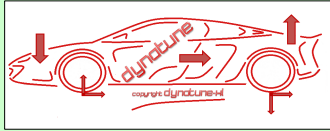
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By Clicking on the DYNATUNE Logo one can go to the corresponding BDM Page on the DYNATUNE-XL Website

**Setting Up the Tool**

If not automatically set, enable the automatic iterations feature in excel options / formulas.

If your computer has less than 4GB of RAM and is not Core i5/i7 then the sheet can be slow due to automatic recalculation at each input. Automatic recalculation can be disabled in Excel Options Menu and updating can be executed by using F9.

If sheet iterations produce inconsistent results, set Threshold Pressure calculation variable to 0. Then reset to original value. Alternatively Push the RESET BUTTON

RESET

**Running The Tool**

- Enter Brake System Data for Front & Rear Wheel. The most important ones are:

**FRONT WHEEL BRAKE DATA & CALCULATIONS**

Select Caliper Type - Floating Caliper / Fixed Caliper

|   |                         |
|---|-------------------------|
| Select Caliper Type - Floating Caliper / Fixed Caliper  | FLOAT                   |
| Piston 1 Size Diameter                                  | 60.00 mm                |
| Piston 1 Type Number of Pistons / HALF Caliper (inside) | 1                       |
| Piston 2 Size / Diameter                                | 35.00 mm                |
| Piston 2 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Piston 3 Size / Diameter                                | 25.00 mm                |
| Piston 3 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Total Piston Area for HALF Caliper                      | 2827.43 mm <sup>2</sup> |
| Total Piston Circumference for HALF Caliper             | 188.50 mm               |
| EQUIVALENT Piston Diameter for Floating Caliper         | 60.00 mm                |
| Threshold Pressure (Pressure Loss due to Friction)      | 0.94 bar                |
| Brake Disc Outer Diameter                               | 243.0 mm                |
| Effective Disc Diameter (calculated w/ Brake Pad Width) | 193.0 mm                |
| Brake Pad Width (in Disc Radius direction)              | 50.0 mm                 |
| Brake Pad Area (1 Pad)                                  | 4000.00 mm <sup>2</sup> |
| Friction Coefficient Brake Pad $\mu$                    | 0.5                     |
| Brake Factor C (=2 x $\mu$ )                            | 1.00                    |
| Tire Rolling Radius                                     | 285.00 mm               |

Select Type of Caliper: FLOAT or FIXED

Enter Number of Pistons only for one side of the Caliper.

If the Caliper is a Floating one then enter ALL pistons.

If the Caliper is a Fixed one then the number to be entered is the number of pistons in ONE half of the Caliper.

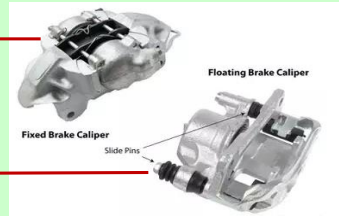
Enter all Piston Dimensions

"FIXED" CALIPER

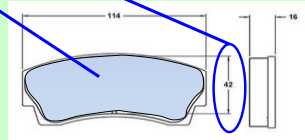
Nr of Pistons / HALF Caliper = 1

"FLOATING" CALIPER

Nr of Pistons / HALF Caliper = 1

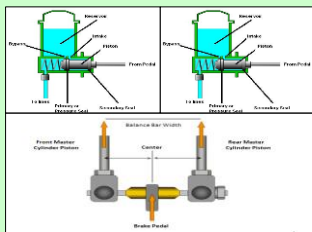


The Friction Coefficients of the Brake Pad is very much depending on the Type of Pad. This Number is typically defined for Cold and Hot conditions and is typically provided by the Brake Pad Manufacturer.

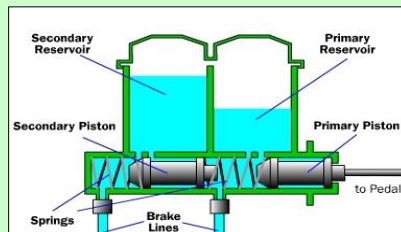


- Enter Brake System Data for Pedal Box and Master Brake Cylinders. The tool can calculate both a Tandem Brake Master Cylinder or a Brake Bias Balance Bar which is typically used in Racing Applications :

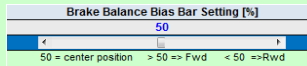
Brake Bias Balance Bar with x 2 Master Cylinders



Tandem Brake Master Cylinder



- Enter Brake Balance Bias Bar Setting - if applicable. Use Slider or enter Number



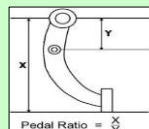
- Select Brake Master Cylinder Configuration

Use Standard OEM Tandem Brake Master Cylinder instead of Brake Balance Bias Bar

- Insert Brake Master Cylinder Hydraulic Dimensions & Pressure Control Valve Limits (if applicable, typically found on the rear circuit)

|  |            |
|--|------------|
| <b>REAR BRAKE SYSTEM DATA &amp; CALCULATIONS</b> |            |
| Rear Master Cylinder Diameter                    | 16.00 mm   |
| Rear Brake Pressure Control Valve Limit          | 500.00 bar |

- Insert Brake Pedal Data - Force Ratio



- Enter System Friction & Compliance Data. Pedal Travel originates from Deformations of System components.

- Typically Piston Seals generate Friction which results in a Pressure Loss in the System. A Typical number is around 0.005 for a standard OEM design

- In BDM all deformations are assumed to be in located in the Brake Pads which are being compressed under Pressure. The number indicates how much the material deforms per unit of pressure. 0 = Zero Travel !

|  |                               |
|--|-------------------------------|
| Threshold Pressure / mm of Piston Circumference          | 0.005 bar/mm                  |
| Pad Deformation / Surface Pressure (Fr. & Rr. Identical) | 0.025 mm/(N/mm <sup>2</sup> ) |

- Enter all Vehicle Data & Load Conditions. Typically Brake Systems are verified in a standard running condition and in a fully loaded scenario

| VEHICLE DATA & LOAD CONDITIONS                       |                     |
|--|---------------------|
| Imposed Vehicle Speed                                | 100.0 kph           |
| Max Tire Grip - Friction Coefficient                 | 1.25                |
| Wheelbase  | 2500 mm             |
| Front Lift Coefficient (Negative = Downforce)        | -0.25               |
| Rear Lift Coefficient (Negative = Downforce)         | -0.50               |
| Drag Coefficient (set to 0 for NO Drag Deceleration) | 0.60                |
| Total Frontal Area                                   | 1.50 m <sup>2</sup> |
| CAR 1 - BALANCE BAR 1 UP                             | 1 UP -Chart Titles  |
| CAR 1 - BALANCE BAR GVW                              | -Chart Titles- GVW  |
| Total Vehicle Mass                                   | 625 750 kg          |
| Vehicle Weight Distribution                          | 50.0 45.0 % Fwd     |
| Center of Gravity Height                             | 350.0 350.0 mm      |
| Front Axle Load (incl. Aerodynamic Loads)            | 3239.2 3484.5 N     |
| Rear Axle Load (incl. Aerodynamic Loads)             | 3412.8 4393.8 N     |

The tool does provide a range of Metrics and Graphs to evaluate the Layout and Performance of the Brake System. The most important ones are briefly explained below.

**Results - Metrics:**

- Percentage Brake Distribution (with & without losses) & Mechanical Position of Balance Bar with respect to Center Position.

| BRAKE SYSTEM RESULTS  | 1 UP  | GVW         |
|---|-------|-------------|
| Static % Brake Distribution on Vehicle (No Friction Losses) | 66.65 | 66.65 % Fwd |
| Brake Balance Distribution on Vehicle @ Max Braking         | 66.54 | 66.55 % Fwd |

| BRAKE BIAS POSITION |           |
|---------------------|-----------|
| Front [mm]          | Rear [mm] |
| 7.8                 | -7.8      |

- Maximum Pedal Force & Pedal Travel (No Brake Booster)

| BRAKE PEDAL RESULTS        | 1 UP   | GVW      |
|----------------------------|--------|----------|
| Pedal Force @ Max Braking  | 910.63 | 992.10 N |
| Pedal Travel @ Max Braking | 4.20   | 4.59 mm  |

- Axle Performance, Maximum Deceleration. The tool does focus on the "mechanical" side.

Any effects of Aerodynamic Braking due to Drag are considered in stopping distances but as they are irrelevant to the fundamental physics of the braking system they are "only" logged for reference.

| GRIP SATURATION - MAX DECELERATION                      | 1 UP  | GVW     |
|---|-------|---------|
| F1: Max Front Axle Grip Saturation occurs @ g:          | 1.343 | 1.205 g |
| F2: Max Rear Axle Grip Saturation occurs @ g:           | 1.356 | 1.338 g |
| Maximum Achievable Deceleration - Hydraulic Brakes Only | 1.34  | 1.20 g  |
| Maximum Hydraulic & Aerodynamic Deceleration            | 1.41  | 1.26 g  |

- Stopping Distance from Imposed Speed. Aerodynamic Effects are considered.

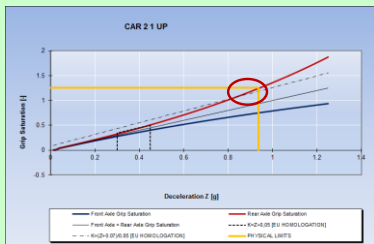
|   | 1 UP  | GVW     |
|---|-------|---------|
| Stopping Distance From Imposed Velocity | 31.95 | 34.17 m |
| Average Deceleration During Stop        | 1.27  | 1.18 g  |

**Results - Graphics**

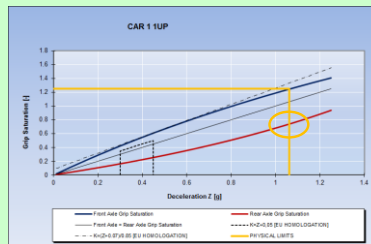
- Overall Performance Graph for various Deceleration Levels. For User Convenience a Typical EU Homologation Requirement for Small Series is included.

**Result are OK when:**

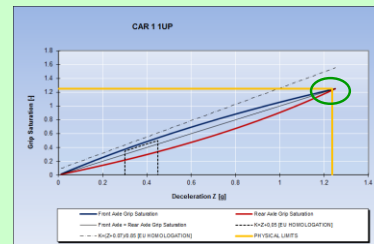
- 1) Front Axle Grip Saturation is above Diagonal Line & below Max. Tire Grip.
- 2) Rear Axle Grip Saturation is below Diagonal Line (and below Front Braking Line).
- 3) Maximum Braking Performance is achieved when Front & Rear Brake Line are as close as possible @ Max. Braking AND are respecting 1) and 2).



Homologation KO - Rear > Homologation Performance KO - Rear > Front



Homologation OK - Front > Rear Performance NOK - Rear << Front



Homologation OK - Front > Rear Performance OK - Rear = Front = Max

The tool does allow to simulate 2 Vehicles at once. In a Custom "COMPARISON" Sheet one can evaluate the main differences between the 2 Vehicles.

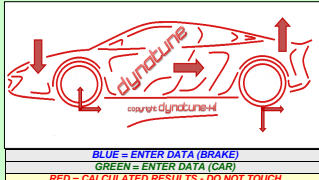
On the USER sheet one can work on a "Normal" Excel Sheet and add ones own custom calculations (if needed). All data from that sheet can be exported to an External Standard .xls workbook.

**UNPROTECTED SHEET FREE FOR USAGE - CANNOT BE RENAMED**

*Can be used as normal Excel Sheet.*

**DO NOT DELETE "EXPORT" BUTTON**

**EXPORT  
COMPLETE USER  
SHEET**



BLUE = ENTER DATA (BRAKE)  
GREEN = ENTER DATA (CAR)  
RED = CALCULATED RESULTS - DO NOT TOUCH

| VEHICLE DATA & LOAD CONDITIONS                       |                     |
|--|---------------------|
| Imposed Vehicle Speed                                | 100.0 kph           |
| Max Tire Grip - Friction Coefficient                 | 1.25                |
| Wheelbase  | 2500 mm             |
| Front Lift Coefficient (Negative = Downforce)        | -0.25               |
| Rear Lift Coefficient (Negative = Downforce)         | -0.50               |
| Drag Coefficient (set to 0 for NO Drag Deceleration) | 0.50                |
| Total Frontal Area                                   | 1.50 m <sup>2</sup> |

| CAR 1 - BALANCE BAR 1 UP                  |                 |
|---|-----------------|
| Chart Titles                              | GWV             |
| Total Vehicle Mass                        | 925 750 kg      |
| Vehicle Weight Distribution               | 50.0 45.0 % Fwd |
| Center of Gravity Height                  | 350.0 350.0 mm  |
| Front Axle Load (incl. Aerodynamic Loads) | 3239.2 3484.5 N |
| Rear Axle Load (incl. Aerodynamic Loads)  | 3412.8 4393.8 N |

NOTE: THIS TOOL DOES NOT CONSIDER ANY BRAKE BOOSTERS!

|   |                               |
|---|-------------------------------|
| See Threshold Pressure to 0 or "Preset" Sheet         |                               |
| Threshold Pressure / mm of Piston Circumference       | 0.025 bar/mm                  |
| Pad Deformation / Surface Pressure (F & Rc Identical) | 0.025 mm/(N/mm <sup>2</sup> ) |

| FRONT BRAKE SYSTEM DATA & CALCULATIONS                      |                             |
|---|-----------------------------|
| Front Brake Master Cylinder Diameter                        | 18.00 mm                    |
| Front Brake Pressure Control Valve Limit                    | 500.00 bar                  |
| Front Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>      |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio   | 11.11                       |
| Oil Displacement for both Front Calipers / mm Piston Travel | 5654.87 mm <sup>3</sup> /mm |
| Front Master Cylinder Travel @ Max Braking                  | 2.25 2.42 mm                |
| Front Master Cylinder Force @ Max Braking                   | 1480.14 1591.79 N           |
| Piston Force on 1 Brake Pad @ Max Braking (Clamp Load)      | 889.76 8710.03 N            |
| Surface Pressure on 1 Brake Pad @ Max Braking               | 2.02 2.18 N/mm <sup>2</sup> |
| Deformation of 1 Brake Pad @ Max Braking                    | 0.051 0.054 mm              |
| Sum of all 4 Pad Deformations on both Front Calipers        | 0.202 0.219 mm              |

| REAR WHEEL BRAKE DATA & CALCULATIONS                    |                         |
|---|-------------------------|
| Select Caliper Type - Floating Caliper / Fixed Caliper  | FLOAT                   |
| Piston 1 Size Diameter                                  | 43.00 mm                |
| Piston 1 Type Number of Pistons / HALF Caliper (inside) | 1                       |
| Piston 2 Size / Diameter                                | 20.00 mm                |
| Piston 2 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Piston 3 Size / Diameter                                | 15.00 mm                |
| Piston 3 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Total Piston Area for HALF Caliper                      | 1452.20 mm <sup>2</sup> |
| Total Piston Circumference for HALF Caliper             | 135.09 mm               |
| EQUIVALENT Piston Diameter for Floating Caliper         | 43.00 mm                |
| Threshold Pressure (Pressure Loss due to Friction)      | 0.58 bar                |
| Brake Disc Outer Diameter                               | 223.0 mm                |
| Effective Disc Diameter (calculated w/ Brake Pad Width) | 186.0 mm                |
| Brake Pad Width (in Disc Radius direction)              | 35.0 mm                 |
| Brake Pad Area (1 Pad)                                  | 3900.00 mm <sup>2</sup> |
| Friction Coefficient Brake Pad $\mu$                    | 1.00                    |
| Brake Factor C (-2 x $\mu$ )                            | 1.00                    |
| Tire Rolling Radius                                     | 285.00 mm               |

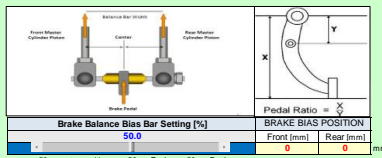
| REAR BRAKE SYSTEM DATA & CALCULATIONS                      |                             |
|--|-----------------------------|
| Rear Master Cylinder Diameter                              | 18.00 mm                    |
| Rear Brake Pressure Control Valve Limit                    | 500.00 bar                  |
| Rear Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>      |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio  | 5.71                        |
| Oil Displacement for both Rear Calipers / mm Piston Travel | 2804.40 mm <sup>3</sup> /mm |
| Rear Master Cylinder Travel @ Max Braking                  | 1.00 1.00 mm                |
| Rear Master Cylinder Force @ Max Braking                   | 1480.14 1591.79 N           |

| FRONT WHEEL BRAKE DATA & CALCULATIONS                   |                         |
|---|-------------------------|
| Select Caliper Type - Floating Caliper / Fixed Caliper  | FLOAT                   |
| Piston 1 Size Diameter                                  | 60.00 mm                |
| Piston 1 Type Number of Pistons / HALF Caliper (inside) | 1                       |
| Piston 2 Size / Diameter                                | 35.00 mm                |
| Piston 2 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Piston 3 Size / Diameter                                | 25.00 mm                |
| Piston 3 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Total Piston Area for HALF Caliper                      | 2827.43 mm <sup>2</sup> |
| Total Piston Circumference for HALF Caliper             | 188.50 mm               |
| EQUIVALENT Piston Diameter for Floating Caliper         | 60.00 mm                |
| Threshold Pressure (Pressure Loss due to Friction)      | 0.94 bar                |
| Brake Disc Outer Diameter                               | 243.0 mm                |
| Effective Disc Diameter (calculated w/ Brake Pad Width) | 193.0 mm                |
| Brake Pad Width (in Disc Radius direction)              | 50.0 mm                 |
| Brake Pad Area (1 Pad)                                  | 4000.00 mm <sup>2</sup> |
| Friction Coefficient Brake Pad $\mu$                    | 0.5                     |
| Brake Factor C (-2 x $\mu$ )                            | 1.00                    |
| Tire Rolling Radius                                     | 285.00 mm               |

| BRAKE SYSTEM RESULTS  |                   |
|---|-------------------|
| Static % Brake Distribution on Vehicle (No Friction Losses) | 66.65 66.65 % Fwd |
| Brake Balance Distribution on Vehicle @ Max Braking         | 66.55 66.56 % Fwd |
| Static Line Pressure Ratio Front to Rear P1/P2              | 1.000 1.000       |
| Front Brake Line Pressure P1 @ Max Braking                  | 58.17 62.55 bar   |
| Rear Brake Line Pressure P2 @ Max Braking                   | 58.17 62.55 bar   |
| Line Pressure Ratio Front to Rear P1/P2 @ Max Braking       | 1.000 1.000       |

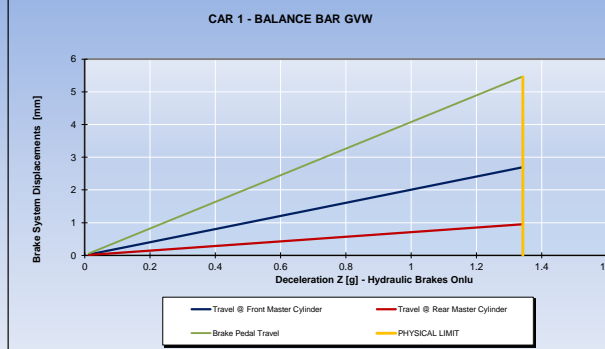
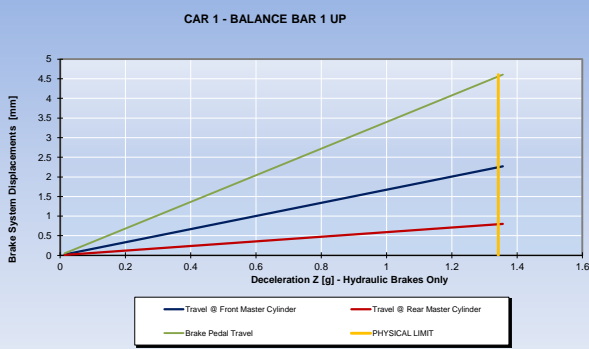
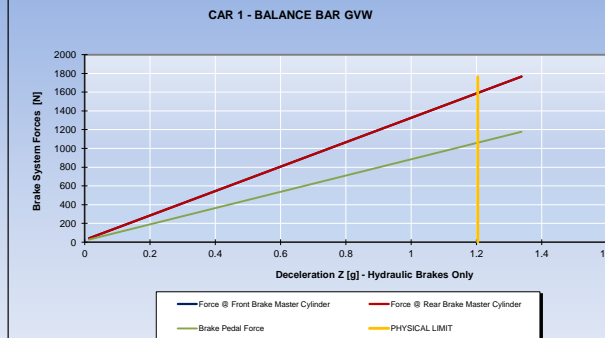
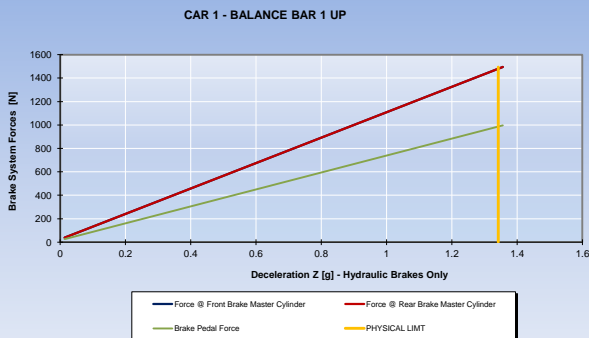
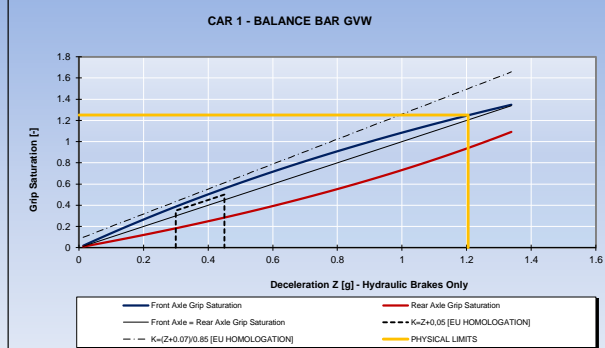
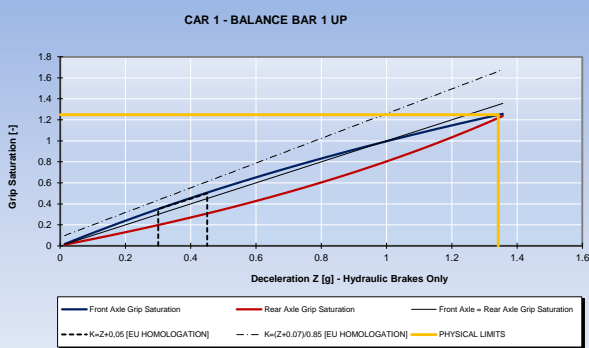
| Car Results   |               |
|---|---------------|
| Deceleration At Imposed Velocity due to Drag Force Only | 0.07 0.06 g   |
| Stopping Distance From Imposed Velocity                 | 30.58 33.26 m |
| Average Deceleration During Stop                        | 1.31 1.21 g   |

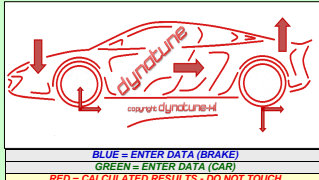
| PEDAL BOX DATA & CALCULATIONS                 |                   |
|---|-------------------|
| Pedal Ratio                                   | 3.90              |
| Balance Bias Bar Width                        | 78.00 mm          |
| Center Bias Bar / Caliper Piston Travel Ratio | 8.41 mm/mm        |
| Pedal Travel / Caliper Piston Travel Ratio    | 25.23 mm/mm       |
| Force @ Center Bias Bar @ Max Braking         | 2960.28 3183.53 N |
| Travel @ Center Bias Bar @ Max Braking        | 1.52 1.64 mm      |



Result are OK when:  
1) Front Axle Grip Saturation Line is above Diagonal Line & below Max. Tire Grip.  
2) Rear Axle Grip Saturation Line is below Diagonal Line (and below Front Braking Line).  
3) Maximum Braking Performance is achieved when Front & Rear Brake Line are as close as possible @ Max. Braking AND are respecting 1) and 2).

If Result KO - Modify Bias Bar Setting / Master Brake Cylinder Diameters / Pressure Control Valve





| VEHICLE DATA & LOAD CONDITIONS               |                     |
|--|---------------------|
| Imposed Vehicle Speed                        | 100.0 kph           |
| Max Tire Grip - Friction Coefficient         | 1.25                |
| Wheelbase                                    | 2500 mm             |
| Rear Lift Coefficient (Negative = Downforce) | -0.25               |
| Rear Lift Coefficient (Negative = Downforce) | -0.50               |
| Drag Coefficient                             | 0.50                |
| Total Frontal Area                           | 1.50 m <sup>2</sup> |
| CAR 2 - TANDEM MASTER 1UP                    | 1 UP - Chart Titles |
| CAR 2 - TANDEM MASTER GWV                    | GWV - Chart Titles  |
| Total Vehicle Mass                           | 925 750 kg          |
| Vehicle Weight Distribution                  | 50.0 45.0 % Fwd     |
| Center of Gravity Height                     | 350.0 350.0 mm      |
| Front Axle Load (incl. Aerodynamic Loads)    | 3239.2 3484.5 N     |
| Rear Axle Load (incl. Aerodynamic Loads)     | 3412.8 4393.8 N     |

NOTE: THIS TOOL DOES NOT CONSIDER ANY BRAKE BOOSTERS!

|   |                               |
|---|-------------------------------|
| See Threshold Pressure to 0 or "Riser" Sheet                          |                               |
| Threshold Pressure / mm of Piston Circumference                       | 0.025 bar/mm                  |
| Pad Deformation / Surface Pressure (F & Rc Identical)                 | 0.025 mm/(N/mm <sup>2</sup> ) |
| If Brake Pad Deformation = 0 then Pad Travel will be 0 in Calculation |                               |

| FRONT WHEEL BRAKE DATA & CALCULATIONS                   |                         |
|---|-------------------------|
| Select Caliper Type - Floating Caliper / Fixed Caliper  | FLOAT                   |
| Piston 1 Size Diameter                                  | 60.00 mm                |
| Piston 1 Type Number of Pistons / HALF Caliper (inside) | 1                       |
| Piston 2 Size / Diameter                                | 31.00 mm                |
| Piston 2 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Piston 3 Size / Diameter                                | 25.00 mm                |
| Piston 3 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Total Piston Area for HALF Caliper                      | 2827.43 mm <sup>2</sup> |
| Total Piston Circumference for HALF Caliper             | 188.50 mm               |
| EQUIVALENT Piston Diameter for Floating Caliper         | 60.00 mm                |
| Threshold Pressure (Pressure Loss due to Friction)      | 0.94 bar                |
| Brake Disc Outer Diameter                               | 283.0 mm                |
| Effective Disc Diameter (calculated w/ Brake Pad Width) | 213.0 mm                |
| Brake Pad Width (in Disc Radius direction)              | 70.0 mm                 |
| Brake Pad Area (1 Pad)                                  | 5509.90 mm <sup>2</sup> |
| Friction Coefficient Brake Pad $\mu$                    | 0.5                     |
| Brake Factor C (=2 x $\mu$ )                            | 1.00                    |
| Tire Rolling Radius                                     | 285.00 mm               |

| REAR WHEEL BRAKE DATA & CALCULATIONS                    |                         |
|---|-------------------------|
| Select Caliper Type - Floating Caliper / Fixed Caliper  | FLOAT                   |
| Piston 1 Size Diameter                                  | 43.00 mm                |
| Piston 1 Type Number of Pistons / HALF Caliper (inside) | 1                       |
| Piston 2 Size / Diameter                                | 22.00 mm                |
| Piston 2 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Piston 3 Size / Diameter                                | 15.00 mm                |
| Piston 3 Type Number of Pistons / HALF Caliper (inside) | 0                       |
| Total Piston Area for HALF Caliper                      | 1452.20 mm <sup>2</sup> |
| Total Piston Circumference for HALF Caliper             | 135.09 mm               |
| EQUIVALENT Piston Diameter for Floating Caliper         | 43.00 mm                |
| Threshold Pressure (Pressure Loss due to Friction)      | 0.58 bar                |
| Brake Disc Outer Diameter                               | 253.0 mm                |
| Effective Disc Diameter (calculated w/ Brake Pad Width) | 216.0 mm                |
| Brake Pad Width (in Disc Radius direction)              | 35.0 mm                 |
| Brake Pad Area (1 Pad)                                  | 3000.00 mm <sup>2</sup> |
| Friction Coefficient Brake Pad $\mu$                    | 0.5                     |
| Brake Factor C (=2 x $\mu$ )                            | 1.00                    |
| Tire Rolling Radius                                     | 285.00 mm               |

| FRONT CALIPER CALCULATIONS                                  |  |
|---|--|
| Front Brake Master Cylinder Diameter                        | 18.00 mm                               |
| Front Brake Pressure Control Valve Limit                    | 500.00 bar                             |
| Front Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>                 |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio   | 11.11 mm <sup>2</sup> /mm <sup>2</sup> |
| Oil Displacement for both Front Calipers / mm Piston Travel | 5654.67 mm <sup>3</sup> /mm            |
|   | 1 UP GWV                               |
| Front Master Cylinder Travel @ Max Braking                  | 1.44 1.60 mm                           |
| Front Master Cylinder Force @ Max Braking                   | 1308.03 1451.82 N                      |
| 1 UP GWV  |  |
| Piston Force on 1 Brake Pad @ Max Braking (Clamp Load)      | 7133.59 7531.34 N                      |
| Surface Pressure on 1 Brake Pad @ Max Braking               | 1.30 1.44 N/mm <sup>2</sup>            |
| Deformation of 1 Brake Pad @ Max Braking                    | 0.032 0.036 mm                         |
| Sum of all 4 Pad Deformations on both Front Calipers        | 0.130 0.144 mm                         |

| BRAKE SYSTEM RESULTS  |                   |
|---|-------------------|
| Static % Brake Distribution on Vehicle (No Friction Losses) | 65.55 65.55 % Fwd |
| Brake Balance Distribution on Vehicle @ Max Braking         | 65.43 65.44 % Fwd |
| Static Line Pressure Ratio Front to Rear P1/P2              | 1.000 1.000       |
| Front Brake Line Pressure P1 @ Max Braking                  | 51.40 57.05 bar   |
| Rear Brake Line Pressure P2 @ Max Braking                   | 51.40 57.05 bar   |
| Line Pressure Ratio Front to Rear P1/P2 @ Max Braking       | 1.000 1.000       |

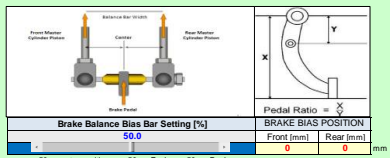
| Car Results   |               |
|---|---------------|
| Deceleration At Imposed Velocity due to Drag Force Only | 0.07 0.06 g   |
| Stopping Distance From Imposed Velocity                 | 30.69 32.21 m |
| Average Deceleration During Stop                        | 1.30 1.24 g   |

| REAR CALIPER CALCULATIONS                                  |                                       |
|--|---------------------------------------|
| Rear Brake Master Cylinder Diameter                        | 18.00 mm                              |
| Rear Brake Pressure Control Valve Limit                    | 500.00 bar                            |
| Rear Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>                |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio  | 5.71 mm <sup>2</sup> /mm <sup>2</sup> |
| Oil Displacement for both Rear Calipers / mm Piston Travel | 2904.40 mm <sup>3</sup> /mm           |
|  | 1 UP GWV                              |
| Rear Master Cylinder Travel @ Max Braking                  | 1.44 1.60 mm                          |
| Rear Master Cylinder Force @ Max Braking                   | 1308.03 1451.82 N                     |
| 1 UP GWV   |                                       |
| Piston Force on 1 Brake Pad @ Max Braking (Clamp Load)     | 3683.28 4093.05 N                     |
| Surface Pressure on 1 Brake Pad @ Max Braking              | 1.23 1.35 N/mm <sup>2</sup>           |
| Deformation of 1 Brake Pad @ Max Braking                   | 0.031 0.034 mm                        |
| Sum of all 4 Pad Deformations on both Rear Calipers        | 0.123 0.136 mm                        |

| REAR BRAKE SYSTEM DATA & CALCULATIONS                      |                                       |
|--|---------------------------------------|
| Rear Master Cylinder Diameter                              | 18.00 mm                              |
| Rear Brake Pressure Control Valve Limit                    | 500.00 bar                            |
| Rear Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>                |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio  | 5.71 mm <sup>2</sup> /mm <sup>2</sup> |
| Oil Displacement for both Rear Calipers / mm Piston Travel | 2904.40 mm <sup>3</sup> /mm           |
|  | 1 UP GWV                              |
| Rear Master Cylinder Travel @ Max Braking                  | 1.44 1.60 mm                          |
| Rear Master Cylinder Force @ Max Braking                   | 1308.03 1451.82 N                     |
| 1 UP GWV   |                                       |
| Piston Force on 1 Brake Pad @ Max Braking (Clamp Load)     | 3683.28 4093.05 N                     |
| Surface Pressure on 1 Brake Pad @ Max Braking              | 1.23 1.35 N/mm <sup>2</sup>           |
| Deformation of 1 Brake Pad @ Max Braking                   | 0.031 0.034 mm                        |
| Sum of all 4 Pad Deformations on both Rear Calipers        | 0.123 0.136 mm                        |

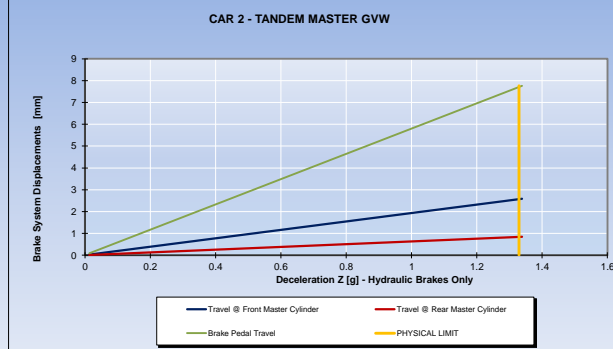
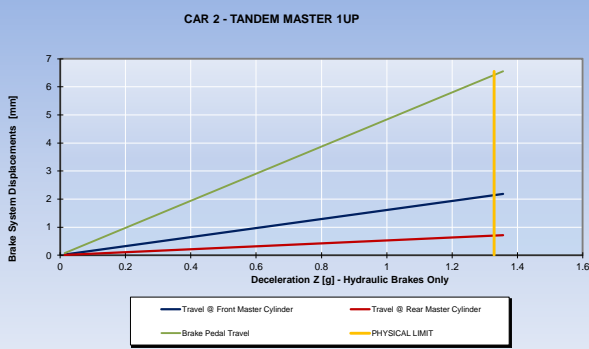
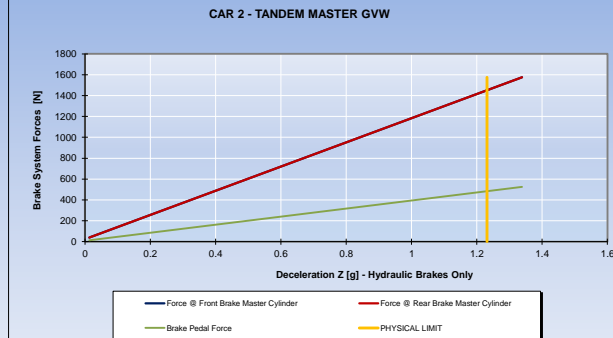
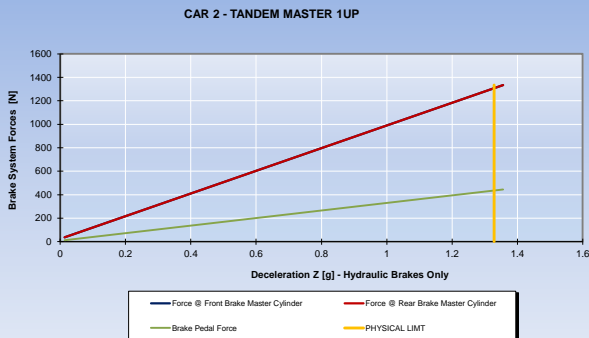
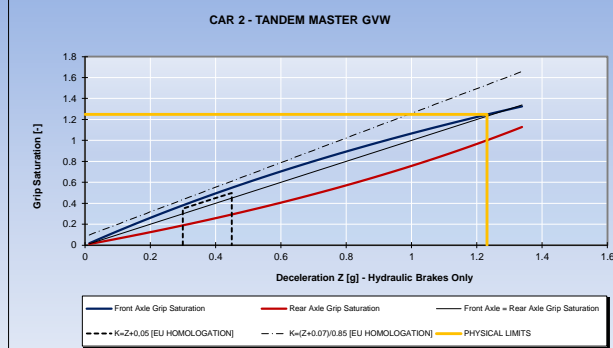
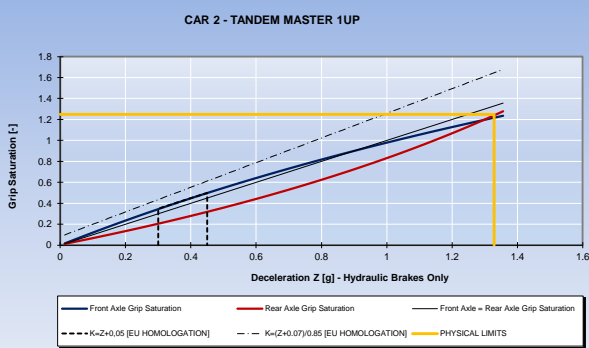
| REAR CALIPER CALCULATIONS                                  |                                       |
|--|---------------------------------------|
| Rear Brake Master Cylinder Diameter                        | 18.00 mm                              |
| Rear Brake Pressure Control Valve Limit                    | 500.00 bar                            |
| Rear Master Cylinder Piston Area                           | 254.47 mm <sup>2</sup>                |
| HALF Caliper Pistons / Master Cylinder Surface Area Ratio  | 5.71 mm <sup>2</sup> /mm <sup>2</sup> |
| Oil Displacement for both Rear Calipers / mm Piston Travel | 2904.40 mm <sup>3</sup> /mm           |
|  | 1 UP GWV                              |
| Rear Master Cylinder Travel @ Max Braking                  | 1.44 1.60 mm                          |
| Rear Master Cylinder Force @ Max Braking                   | 1308.03 1451.82 N                     |
| 1 UP GWV   |                                       |
| Piston Force on 1 Brake Pad @ Max Braking (Clamp Load)     | 3683.28 4093.05 N                     |
| Surface Pressure on 1 Brake Pad @ Max Braking              | 1.23 1.35 N/mm <sup>2</sup>           |
| Deformation of 1 Brake Pad @ Max Braking                   | 0.031 0.034 mm                        |
| Sum of all 4 Pad Deformations on both Rear Calipers        | 0.123 0.136 mm                        |

| PEDAL BOX DATA & CALCULATIONS                 |                   |
|---|-------------------|
| Pedal Ratio                                   | 3.00              |
| Balance Bias Bar Width                        | 78.00 mm          |
| Center Bias Bar / Caliper Piston Travel Ratio | 8.41 mm/mm        |
| Pedal Travel / Caliper Piston Travel Ratio    | 25.23 mm/mm       |
|   | 1 UP GWV          |
| Force @ Tandem Master Cylinder @ Max Braking  | 1308.03 1451.82 N |
| Travel @ Tandem Master Cylinder @ Max Braking | 2.14 2.35 mm      |



Result are OK when:  
 1) Front Axle Grip Saturation Line is above Diagonal Line & below Max. Tire Grip.  
 2) Rear Axle Grip Saturation Line is below Diagonal Line (and below Front Braking Line).  
 3) Maximum Braking Performance is achieved when Front & Rear Brake Line are as close as possible @ Max. Braking AND are respecting 1) and 2).

If Result KO - Modify Bias Bar Setting / Master Brake Cylinder Diameters / Pressure Control Valve



**VEHICLE 1**

CAR 1 - BALANCE BAR 1 UP  
CAR 1 - BALANCE BAR GWV

| BRAKE SYSTEM RESULTS  |  | 1 UP  | GWV   |       |
|---|--|-------|-------|-------|
| Static % Brake Distribution on Vehicle (No Friction Losses) |  | 66.65 | 66.65 | % Fwd |
| Brake Balance Distribution on Vehicle @ Max Braking         |  | 66.55 | 66.56 | % Fwd |
| Static Line Pressure Ratio Front to Rear P1/P2              |  | 1.000 | 1.000 | -     |
| Front Brake Line Pressure P1 @ Max Braking                  |  | 58.17 | 62.55 | bar   |
| Rear Brake Line Pressure P2 @ Max Braking                   |  | 58.17 | 62.55 | bar   |
| Line Pressure Ratio Front to Rear P1/P2 @ Max Braking       |  | 1.000 | 1.000 | -     |

| BRAKE PEDAL RESULTS        |  | 1 UP   | GWV     |    |
|----------------------------|--|--------|---------|----|
| Pedal Force @ Max Braking  |  | 986.76 | 1061.19 | N  |
| Pedal Travel @ Max Braking |  | 4.56   | 4.91    | mm |

| GRIP SATURATION - MAX DECELERATION                      |  | 1 UP  | GWV   |   |
|---|--|-------|-------|---|
| F1: Max Front Axle Grip Saturation occurs @ g:          |  | 1.343 | 1.205 | g |
| F2: Max Rear Axle Grip Saturation occurs @ g:           |  | 1.356 | 1.338 | g |
| Maximum Achievable Deceleration - Hydraulic Brakes Only |  | 1.34  | 1.20  | g |
| Maximum Hydraulic & Aerodynamic Deceleration            |  | 1.41  | 1.26  | g |

| Car Parameters                       |  |       |     |
|--------------------------------------|--|-------|-----|
| Imposed Vehicle Speed                |  | 100.0 | kph |
| Max Tire Grip - Friction Coefficient |  | 1.25  | -   |
| Brake Balance Bias Bar Setting [%]   |  | 50    | -   |

| Stopping Distance From Imposed Velocity |  | 1 UP  | GWV   |   |
|---|--|-------|-------|---|
| Stopping Distance From Imposed Velocity |  | 30.58 | 33.26 | m |
| Average Deceleration During Stop        |  | 1.31  | 1.21  | g |

**VEHICLE 2**

CAR 2 - TANDEM MASTER 1UP  
CAR 2 - TANDEM MASTER GWV

| BRAKE SYSTEM RESULTS  |  | 1 UP  | GWV   |       |
|---|--|-------|-------|-------|
| Static % Brake Distribution on Vehicle (No Friction Losses) |  | 65.55 | 65.55 | % Fwd |
| Brake Balance Distribution on Vehicle @ Max Braking         |  | 65.43 | 65.44 | % Fwd |
| Static Line Pressure Ratio Front to Rear P1/P2              |  | 1.000 | 1.000 | -     |
| Front Brake Line Pressure P1 @ Max Braking                  |  | 51.40 | 57.05 | bar   |
| Rear Brake Line Pressure P2 @ Max Braking                   |  | 51.40 | 57.05 | bar   |
| Line Pressure Ratio Front to Rear P1/P2 @ Max Braking       |  | 1.000 | 1.000 | -     |

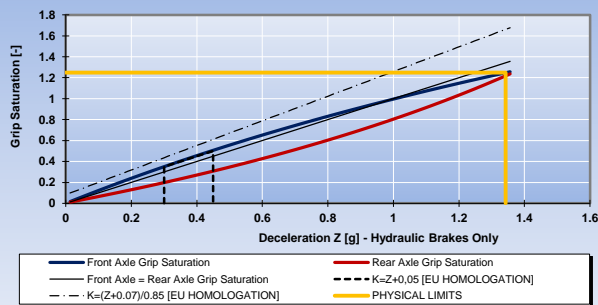
| BRAKE PEDAL RESULTS        |  | 1 UP   | GWV    |    |
|----------------------------|--|--------|--------|----|
| Pedal Force @ Max Braking  |  | 436.01 | 483.87 | N  |
| Pedal Travel @ Max Braking |  | 6.43   | 7.14   | mm |

| GRIP SATURATION - MAX DECELERATION                      |  | 1 UP  | GWV   |   |
|---|--|-------|-------|---|
| F1: Max Front Axle Grip Saturation occurs @ g:          |  | 1.356 | 1.231 | g |
| F2: Max Rear Axle Grip Saturation occurs @ g:           |  | 1.329 | 1.338 | g |
| Maximum Achievable Deceleration - Hydraulic Brakes Only |  | 1.33  | 1.23  | g |
| Maximum Hydraulic & Aerodynamic Deceleration            |  | 1.40  | 1.29  | g |

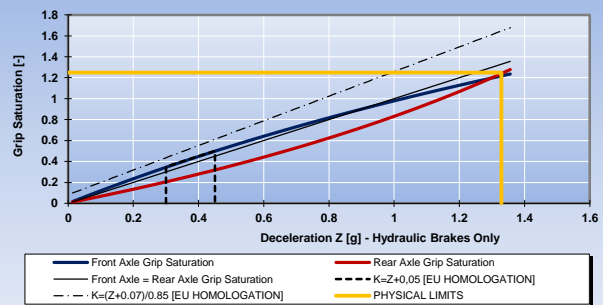
| Car Parameters                       |  |       |     |
|--------------------------------------|--|-------|-----|
| Imposed Vehicle Speed                |  | 100.0 | kph |
| Max Tire Grip - Friction Coefficient |  | 1.25  | -   |
| Brake Balance Bias Bar Setting [%]   |  | 50    | -   |

| Stopping Distance From Imposed Velocity |  | 1 UP  | GWV   |   |
|---|--|-------|-------|---|
| Stopping Distance From Imposed Velocity |  | 30.69 | 32.21 | m |
| Average Deceleration During Stop        |  | 1.30  | 1.24  | g |

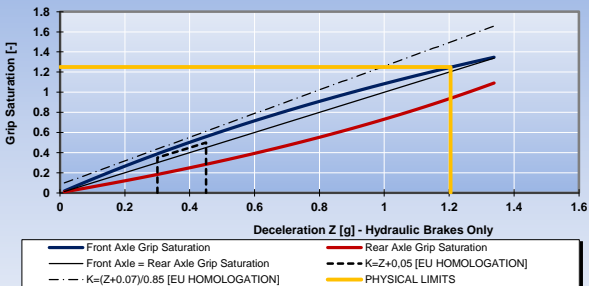
CAR 1 - BALANCE BAR 1 UP



CAR 2 - TANDEM MASTER 1UP



CAR 1 - BALANCE BAR GWV



CAR 2 - TANDEM MASTER GWV

