



## DIY Wheel Alignment

### Do-It-Yourself Alignment by Calvin Sanders

*Grateful thanks to Calvin Sanders and "The Vintage Triumph Register" (<http://www.vtr.org>) for the following article.*

I received a lot of interest from fellow British Car owners when I mentioned doing my own alignments with homemade tools, so I took a couple of days and put together this explanation of how I do it, and what tools I use.

When I first said it took \$20 in tools I made a quick guess off the top of my head, but here is what you need and a guess of the cost.

- » 15' of clear vinyl tubing about 5/16" diameter \$3.00 2 12" rulers – swipe from office supply at work
- » \$0.00 10-20 pieces of fairly stiff floor tiles 12X12" left over from the last time you replaced kitchen floor \$2.00
- » 16" bubble level from Roses on sale \$3.00 Piece of wood long enough to span one wheel from lip to lip \$0.00
- » 6" machinists ruler with 1/32" or better markings \$4.00
- » Carpenters Plumbob on sale at Sears \$2.00
- » Some kind of fixture for measuring Caster \$????
- » Fishing line – about 40 feet \$1.00
- » 4 jack stands – should already have \$0.00
- » Magnetic base carpenters Protractor \$4.00

Some other ones may help. A Lucas or similar digital protractor is a great tool. If I were to spend much money on any one tool it would be one of these. I think they are about \$90, but if anything is worth the money they are. They will just make the job much easier.

OK first make sure your tires all have proper air pressure in them. First you will need to find a level spot. For this I use clear tape and attach the two rulers to the ends of the clear vinyl tubing. then you fill the tubing with water. I usually use the tubing like a straw and draw the water up into the tubing. You need two people to use this as a water level. The idea is the water will be level at both ends of the tubing when the tubing is held upright. You can then stand one ruler where one wheel will be and the other ruler where another tire will be and if the water is at the same level on the two rulers then those two spots are level. You can then adjust the "pads" where the tires will be by making stacks of tile. Each tile is usually about 1/8" thick so it takes a few tiles to bring up all the low spots up to the highest spot. In your garage you may want to mark these spots and take notes of how many tiles each place needs.

Next you need to find out how true your rims are. I jack up each wheel and sit the jack stand next to the wheel and sit the machinist's ruler on the jack stand with it extending just to the rim. Then rotate the wheel one turn and see how much run out you have. On most alloy wheels they will have less than 1/32" which is just fine. On factory steel wheels some wheels may have as much as 1/4" which will ruin your measurements. Find 2 places on your wheel that are 180 degrees apart and have the same run out measurement. On almost all wheels there is 2 places you can use to measure on, though you may have to search for the spot. I then mark the spots with a pencil or magic marker.

Alternatively you can either check the tire for trueness and use the tire for measuring, or you can make chalk marks around the tire on the edge of the tread and use a nail or something sharp to make a scribe line around the tread surface near the outside and make all measurements to the

scribe line. To do this jack the wheel up so it can spin freely and drive a nail through a piece of wood. Lay the piece of wood on the floor so that the point of the nail just touches the tire tread. When the tire is spun around you will have a true line scratched around the tire. I have found this method of measuring to not be as convenient as using the rim, so use the rim if it is possible. If your rims are true you can assume them to always be true unless you run over a curb or something. This means you don't have to check them every time you align your car.

Next I like to find the centerline of my car. I do this by using the plum bob draped over my inner suspension mounting points and measuring half way between them and finding the center-line. This of course does not work on all cars. Some cars don't have suspensions that are mirrors of each other, but most do. I will drop the plum bob to the floor and make pencil marks on the floor. Then I will measure on the floor. I found a friend's Corvette to have a perfectly straight frame, but to body of the car to be about 1/2" crooked on the frame. You can't go by the center of the bumper or anything like this. Once you have found the C/L carry the mark up to the chassis or body. I made a fine white line on the front of the frame and the rear of the body under the bumper on my Mustang GT with a paint marker. Now I measure from the centerline for all measurements.

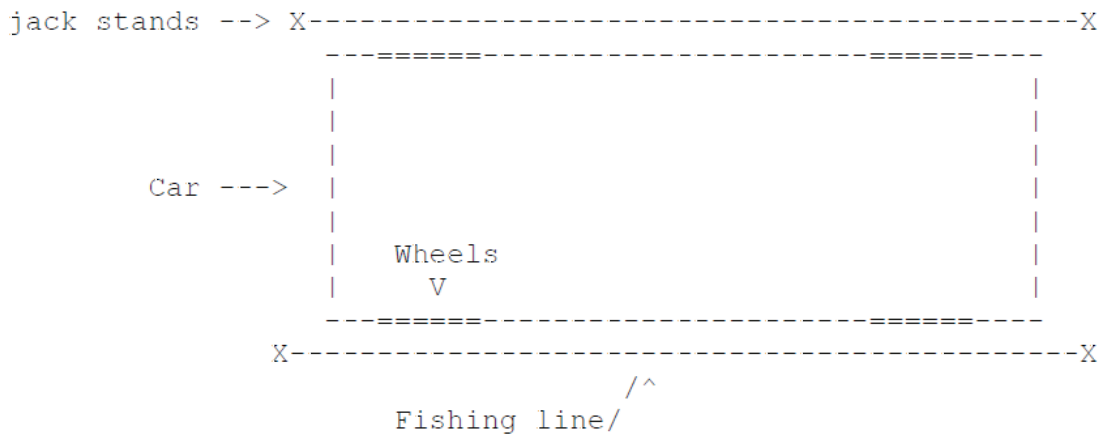
Now put the car on the leveled pads. It is best to have rolled the car back and forth a few times to get the suspension settled. Also I should mention that I have made pads out of one square foot cuts of 2"X12" boards with small angled ramps on the fronts of them. This lifts the car up 2" making suspension parts easier to get to. I then level with the tiles on top of these pads. It works fairly well making the suspension parts easier to reach.

First I like to check the castor. I seldom make any changes to this adjustment. It is also not that critical to have exactly to some spec, but it is important to have each side even. For this I use the Magnetic base protractor. It is accurate to .5 degrees which I think is adequate for castor measurement. On a Strut car I simply place it on the strut and measure the angle of the strut. This may be off slightly from the spec books, but the error is correct from side to side and it is fairly close. If you have a car with upper ball joints first check your spindles for a machined flat spot that is parallel with the ball joint axis. If this exists then you can simply place the protractor on this surface and measure castor. Many cars have this machined surface for various reasons. If it doesn't then all is not lost. You will need to make some sort of fixture that will "reach in" to the ball joints. You will need a vertical flat surface with two "arms" extending to the ball joints. A 2X4 with 2 long bolts through it may work. You want a vertical surface parallel with the ball joint axis. You can measure this with the surface with the protractor again. You can also measure this in a similar method to how I will measure camber later for more accuracy. This is of course only necessary if your car has some way to adjust castor, which many do not.

Next I like to measure camber. This is the most important measurement in auto cross in most people's opinion. I use the short level attached to a piece of wood and the machinists ruler for this. I cut the piece of wood so that it will span across from the top wheel lip to the bottom one. I then attach the level to the piece of wood. I use the wood for a couple of reasons. First I can shim between the wood and the level to correct for errors that may occur in the cheap level. I have found most of them to have some small inaccuracies in them. Also you may need to notch the wood to clear the wheel in the center for the hub or something. I also have different lengths of wood for the different wheel diameters I work with. To correct for errors I use the plumbob. It will hang vertical. I then shim between the wood and the level until it is indicating level when the board is completely vertical.

Now you must have the two places on your wheel you found to be true to each other, vertical (straight up and down). If your entire wheel is true then it is a great benefit at this point. Take the piece of wood and the level and span across your rim with the level vertical. Now use the bubble and pull out from the top of the wheel until you are holding the level vertical. Now measure from the piece of wood to the top of your rim. It will be a distance of about 1/4" or so (assuming you have negative camber. Take this measurement with the machinists ruler. Be as accurate as you can. Then you need to take that distance and divide it by the span distance of the piece of wood. For a 15" wheel you can just use 15" and a 16" wheel 16" etc. Then look up this number in your old Trig table in your high school trig book. You will need to find the arc tangent of the number you have. The degrees of this will be the camber angle. I have a 10 line basic program that will print a chart for converting these angles I have included in the end of this. I have also included a chart that will convert this measurement without dividing and looking up the measurement. I now prefer to keep my measurements in inches of gap at the top of the wheel rather than converting them to degrees. I keep my log books in this measurement rather than degrees for each car. It only causes a problem if I change the rim diameters of any one car I am working with. For toe in measurement I need to reference the centerline of the car.

First you need to get the measuring points on your wheels at 9 and 3 o'clock. This is where it is helpful to have true wheels, then you don't have to move the car. You will need the jack stands and fishing line for this, plus the machinists ruler. you want to set up the fishing line outside the sides of the car an equal distance from the centerline of the car. I tie the fishing line to the jackstands so that the line when stretched will be about equal height to the center of the wheel hubs. This does not have to be exact, but close to the wheel hub center. measure out from the centerline to about 3" outside the wheels. The setup will look like this when viewed from above:



It's important to get the fishing line parallel to the centerline of the car. You can't measure to the rocker panel or the wheel hubs or anything initially because they may or may not be parallel to the centerline. So the first time measure from the centerline that you found before. Now it is good to then measure from the bottom corners of the door or the rocker panel or something and record the measurement in your log book. It will make the setup much faster if you want to change your toe quickly at an event. It should be noted that a perfectly level pad is not necessary for toe setting. It is good to get the car on a fairly level spot but exactly level is not important.

Then to measure the toe measure at the front edge of the rim and the rear edge of the rim and subtract the difference. That will give you the toe measurement. Obviously for toe in the measurement at the rear of the wheel (from the fishing line to the edge of the rim) will be less than the measurement at the front of the wheel. The reverse is true for toe out and the two measurements will be equal for zero toe. The measurements you will be working with will actually be less than what is usually referenced in spec books because the diameter you are working with is the rim diameter, the measurement most cars use is taken at the tread surface, so you may need to make some conversions depending on the specs for your car. Find out how the specs you are working with are measured. Some cars give angles of toe in degrees, some are inches of toe on each side, and some are total toe added together between the sides. Make sure you are working with apples and apples not apples and oranges. Each time you make a toe adjustment recheck your steering wheel if you have not locked it. When you adjust one side the steering wheel usually moves and must be re-centered before you take new measurements. Locking the wheel some way will make the job easier.

As you are making changes take a note of what one shim here and one turn of the tie rod there changes and how much. You will notice that a camber change changes the toe drastically, but as toe change does very little to the camber, etc. When you get used to these things then changing your toe settings as you are changing your tires at an event is a rather simple matter and changing it back to the original toe setting when it is time to drive home is easy if you have made a few marks.

On my Mustang GT I have marked the strut tops as to what change is what camber and I have 2 marks on each tie rod end. I used to change the camber and toe at each event, but I now leave the negative camber in and dial in a little extra toe-out before an event and can feel confident about resetting it correctly before I drive home. I check it occasionally just to make sure the frame hasn't changed. It takes a couple of hours the first time, but once you have done this a couple of times you can do a complete check of your alignment in a couple of minutes in your garage and at an event you can locate a flat spot and check a car completely before you run. It is really fairly easy to do once you get used to it. Here is the chart I promised. It goes up to 6 degrees of camber. The way you use it is to look up the gap between the level and the rim at the top on the diameter rim you are using and look on the left column and find the number of degrees. I have included the tangent of the angle just for good measure.

This is a hard process to explain without hands on aids. I taught a seminar for our sports car club on how to do this and everyone thought it was easy after they did it a few times. I got several phone calls the day after the seminar as everyone went home to do it for the first time themselves, but they were all able to align their own cars correctly. It is really easy to do and it gives you a great deal of confidence in how your car was set up. I will try to answer all questions. I'm sure I was not as clear as I would have hoped to be in some places. Calvin Sanders

deg	tan	17	16	15	14	13
0.1	.0017	0.0297	0.0279	0.0262	0.0244	0.0227
0.2	.0035	0.0593	0.0559	0.0524	0.0489	0.0454
0.3	.0052	0.0890	0.0838	0.0785	0.0733	0.0681
0.4	.0070	0.1187	0.1117	0.1047	0.0977	0.0908
0.5	.0087	0.1484	0.1396	0.1309	0.1222	0.1134
0.6	.0105	0.1780	0.1676	0.1571	0.1466	0.1361
0.7	.0122	0.2077	0.1955	0.1833	0.1711	0.1588
0.8	.0140	0.2374	0.2234	0.2095	0.1955	0.1815
0.9	.0157	0.2671	0.2513	0.2356	0.2199	0.2042
1.0	.0175	0.2967	0.2793	0.2618	0.2444	0.2269
1.1	.0192	0.3264	0.3072	0.2880	0.2688	0.2496
1.2	.0209	0.3561	0.3352	0.3142	0.2933	0.2723
1.3	.0227	0.3858	0.3631	0.3404	0.3177	0.2950
1.4	.0244	0.4155	0.3910	0.3666	0.3422	0.3177
1.5	.0262	0.4452	0.4190	0.3928	0.3666	0.3404
1.6	.0279	0.4749	0.4469	0.4190	0.3911	0.3631
1.7	.0297	0.5045	0.4749	0.4452	0.4155	0.3858
1.8	.0314	0.5342	0.5028	0.4714	0.4400	0.4085
1.9	.0332	0.5639	0.5308	0.4976	0.4644	0.4313
2.0	.0349	0.5937	0.5587	0.5238	0.4889	0.4540
2.1	.0367	0.6234	0.5867	0.5500	0.5134	0.4767
2.2	.0384	0.6531	0.6147	0.5762	0.5378	0.4994
2.3	.0402	0.6828	0.6426	0.6025	0.5623	0.5221
2.4	.0419	0.7125	0.6706	0.6287	0.5868	0.5449
2.5	.0437	0.7422	0.6986	0.6549	0.6113	0.5676
2.6	.0454	0.7720	0.7266	0.6811	0.6357	0.5903
2.7	.0472	0.8017	0.7545	0.7074	0.6602	0.6131
2.8	.0489	0.8314	0.7825	0.7336	0.6847	0.6358
2.9	.0507	0.8612	0.8105	0.7599	0.7092	0.6586
3.0	.0524	0.8909	0.8385	0.7861	0.7337	0.6813
3.1	.0542	0.9207	0.8665	0.8124	0.7582	0.7041
3.2	.0559	0.9504	0.8945	0.8386	0.7827	0.7268
3.3	.0577	0.9802	0.9226	0.8649	0.8072	0.7496
3.4	.0594	1.0100	0.9506	0.8912	0.8318	0.7723
3.5	.0612	1.0398	0.9786	0.9174	0.8563	0.7951
3.6	.0629	1.0695	1.0066	0.9437	0.8808	0.8179
3.7	.0647	1.0993	1.0347	0.9700	0.9053	0.8407
3.8	.0664	1.1291	1.0627	0.9963	0.9299	0.8635
3.9	.0682	1.1589	1.0908	1.0226	0.9544	0.8863
4.0	.0699	1.1888	1.1188	1.0489	0.9790	0.9090
4.1	.0717	1.2186	1.1469	1.0752	1.0035	0.9319
4.2	.0734	1.2484	1.1750	1.1015	1.0281	0.9547
4.3	.0752	1.2782	1.2030	1.1279	1.0527	0.9775
4.4	.0769	1.3081	1.2311	1.1542	1.0772	1.0003
4.5	.0787	1.3379	1.2592	1.1805	1.1018	1.0231
4.6	.0805	1.3678	1.2873	1.2069	1.1264	1.0460
4.7	.0822	1.3977	1.3154	1.2332	1.1510	1.0688
4.8	.0840	1.4275	1.3436	1.2596	1.1756	1.0916
4.9	.0857	1.4574	1.3717	1.2860	1.2002	1.1145
5.0	.0875	1.4873	1.3998	1.3123	1.2248	1.1374
5.1	.0892	1.5172	1.4280	1.3387	1.2495	1.1602
5.2	.0910	1.5471	1.4561	1.3651	1.2741	1.1831
5.3	.0928	1.5770	1.4843	1.3915	1.2987	1.2060
5.4	.0945	1.6070	1.5124	1.4179	1.3234	1.2289
5.5	.0963	1.6369	1.5406	1.4443	1.3480	1.2518
5.6	.0981	1.6669	1.5688	1.4708	1.3727	1.2747
5.7	.0998	1.6968	1.5970	1.4972	1.3974	1.2976
5.8	.1016	1.7268	1.6252	1.5236	1.4221	1.3205
5.9	.1033	1.7568	1.6534	1.5501	1.4468	1.3434
6.0	.1051	1.7868	1.6817	1.5766	1.4715	1.3664