Align it Right!

How to properly align your GMC yourself right in your own driveway

By Jerry Work
GMCWS rally
Casa de Fruita, CA
Spring 2012

Simple concepts, confusing language

- Wheel alignment is a really simple concept that has been wrapped in arcane and confusing language
- If you are designing a vehicle, the concepts are technically challenging and far from a slam dunk
- But if you just want to make sure your car, truck or GMC is properly aligned, it is quite simple and easy to understand

Let's get right to it....

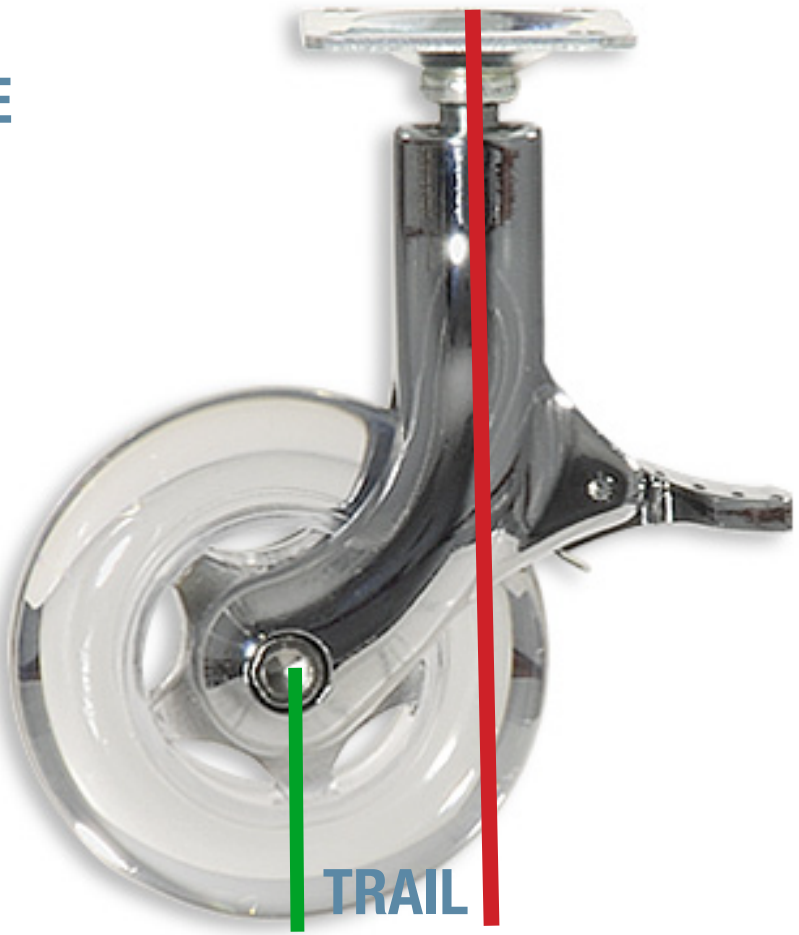
- Draw an imaginary Red line through the pivot point of a wheel and a Green line straight down to the center of the tire's contact with the road.
- The distance the green line trails where the red line hits the road is called (drum roll please)...TRAIL
- If you want to get fancy, call the angle between these two lines CASTER, but it is easier to simply measure the TRAIL

HERE IS A TYPICAL “CASTER” WHEEL LIKE YOU MIGHT FIND ON YOUR TOOLBOX OR ON THE FRONT OF A CART IN YOUR FAVORITE STORE.

THE RED LINE IS THE CENTER OF THE PIVOT POINT AND THE GREEN LINE IS THE CENTER OF WHERE THE TIRE CONTACTS THE GROUND.

THE DISTANCE BETWEEN THESE IS THE AMOUNT OF TRAIL.

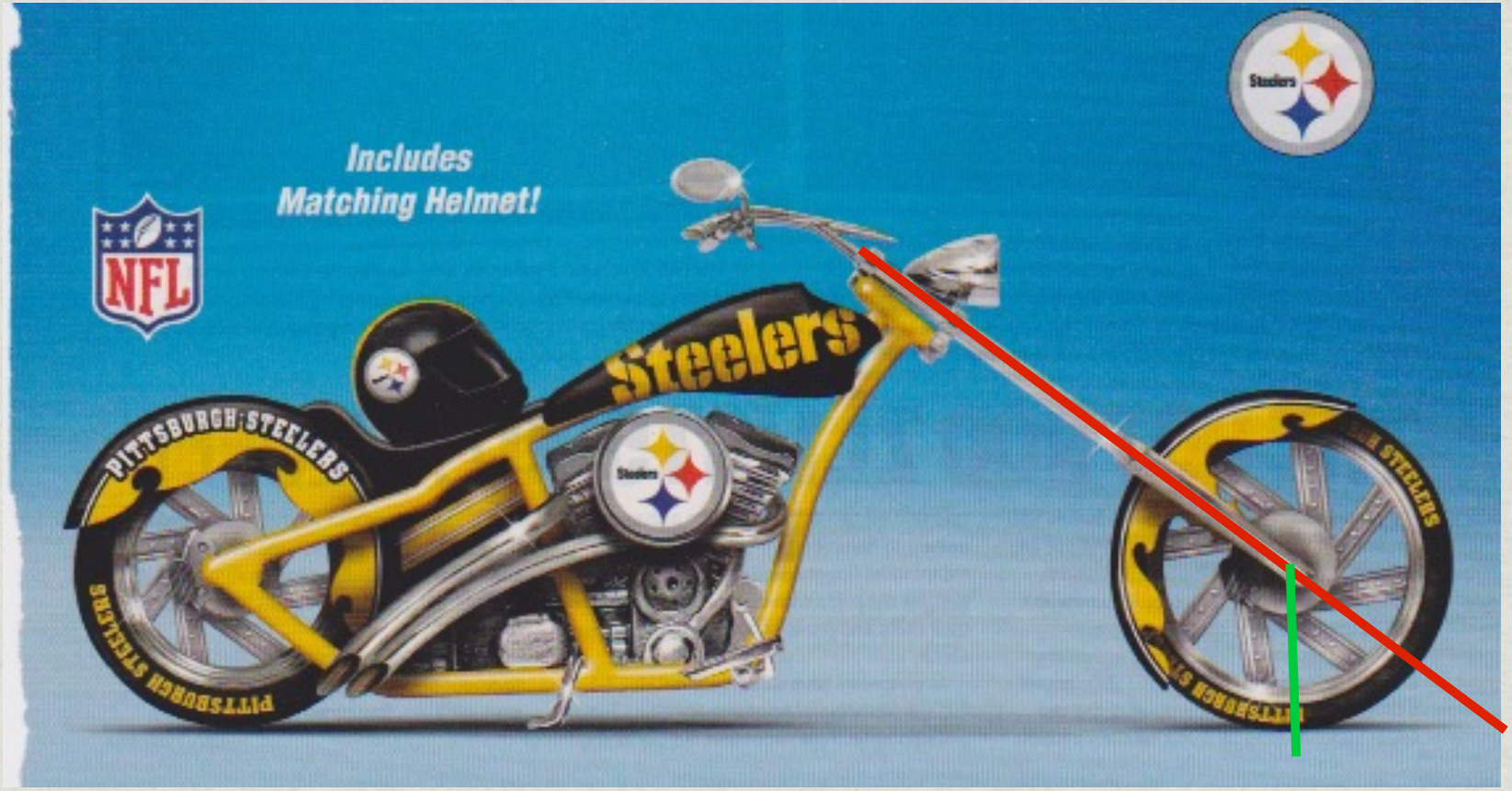
THE GREATER THE TRAIL, THE MORE THE WHEEL WILL STAY OBEDIENTLY BEHIND THE TURNING CENTER, & THE EASIER IT IS TO GO STRAIGHT



THIS IS A TOURING BIKE, SET UP FOR LONG DISTANCE TRAVEL SO IT HAS LOTS OF "TRAIL" BUILT INTO THE FRAME GEOMETRY. IT IS EASY FOR THE RIDER TO KEEP IT GOING STRAIGHT, BUT IT IS NOT AS RESPONSIVE AS A "RACING" BIKE - IT WON'T TURN AS QUICKLY

THIS IS A “RACING” BIKE, SET UP FOR SPIRITED RIDING SO IT HAS MUCH LESS “TRAIL” BUILT INTO THE FRAME GEOMETRY. IT IS EASY FOR THE RIDER TO TURN, BUT HARDER FOR THE RIDER TO KEEP IT GOING STRAIGHT. IT WOULD BE CONSIDERED MORE RESPONSIVE BUT LESS STABLE THAN THE TOURING BIKE.

LOOK AT ALL THE TRAIL IN THIS BAD BOY! IT WILL BE EASY TO GO STRAIGHT FOR A COMFORTABLE CRUISE, BUT SURE WON'T BE A CANYON CUTTER!



Concept 1 - Trail

- In car/truck/GMC lingo this is generally called “Caster” and is the angle between the red and green lines
- The greater the caster angle, the easier it is for your GMC to go straight, but the harder it is to turn and the easier it is to return to straight after a corner
- The more weight on the front end, the greater the effects of caster angle - think what happens when you put a case of beer in the front of your cart, it becomes harder to turn
- Heavy trucks usually have less caster since greater caster would mean far greater strain put on the steering gear

Here is a real curiosity....

- Prior to 1975 most US cars were designed with negative trail (caster), why????
- because we craved cars that were easy to turn at low speeds and then most cars had biased ply tires where the contact patch would distort back at speed (think of a cartoon character of a tire)
- This meant that the car could have really light steering at low speed and become more stable at high speeds as the caster became progressively more positive due to this bias ply tire distortion

....curiosity

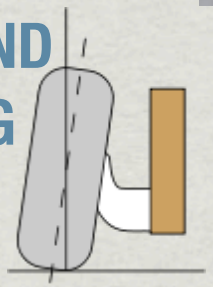
- This is why when you put radial ply tires on this kind of car it will wander all over the road unless you also change the caster significantly since the contact patch does not distort with radial tires so the caster remains negative at speed.
- I can find no record of whether GM physically changed the steering geometry or not when they changed to radial ply tires, but the specs actually went the other way which sure suggests our coaches will benefit a bunch from dialing in more positive caster now that most run radial ply tires.
- 73 spec was +3 deg, 75/76 was +2 deg, 78 was +2 deg.
- Toronados were -2 deg 68-75, 0 75-78 & +2.5 79-80

Concept 2 - Camber

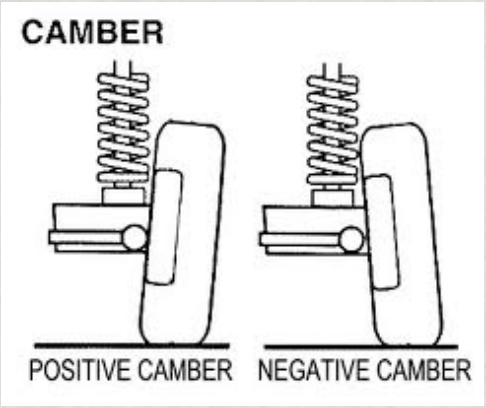
- When a wheel is standing straight up and down it is said to have no camber, or leaning angle.
- The tread is flat on the road for maximum contact patch and even wear while going straight
- Tilt the tire in at the top and the inside edge of the tire will wear more quickly than the outside as it is carrying more weight while going straight. As the car leans going around a corner the tire will stand up straighter putting more of the contact patch on the road than if the tire started out standing straight up. So the car will “stick” better in the turn, but at the expense of more rapid tire wear going straight

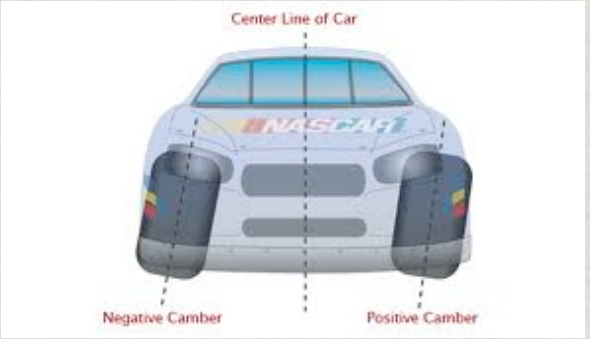
KEEP YOUR GMC FRONT WHEELS STRAIGHT UP AND DOWN WHICH IS CALLED “ZERO CAMBER”

LEAVE ALL THE +- CAMBER STUFF FOR SPECIAL APPLICATIONS LIKE YOUR BACK WHEELS WHERE YOU WANT UP TO 2 DEGREES OF TIRE TOP IN (NEGATIVE) CAMBER TO KEEP THE BACK END FROM OVER STEERING WHILE CORNERING



TYPICAL CAMBER TIRE WEAR PATTERN





Concept 3 - toe

- When both front tires are running parallel with the frame and with each other, the toe is said to be “zero” and you will achieve maximum tire wear
- That is what you want for all six wheels on your GMC
- Some claim that on a front wheel drive vehicle the front wheels will tend to spay out under power so you want the tires closer together at the front than at the rear while at rest
- I have not found real world evidence of that with a GMC so I think zero toe is best unless something else is wrong with your front suspension

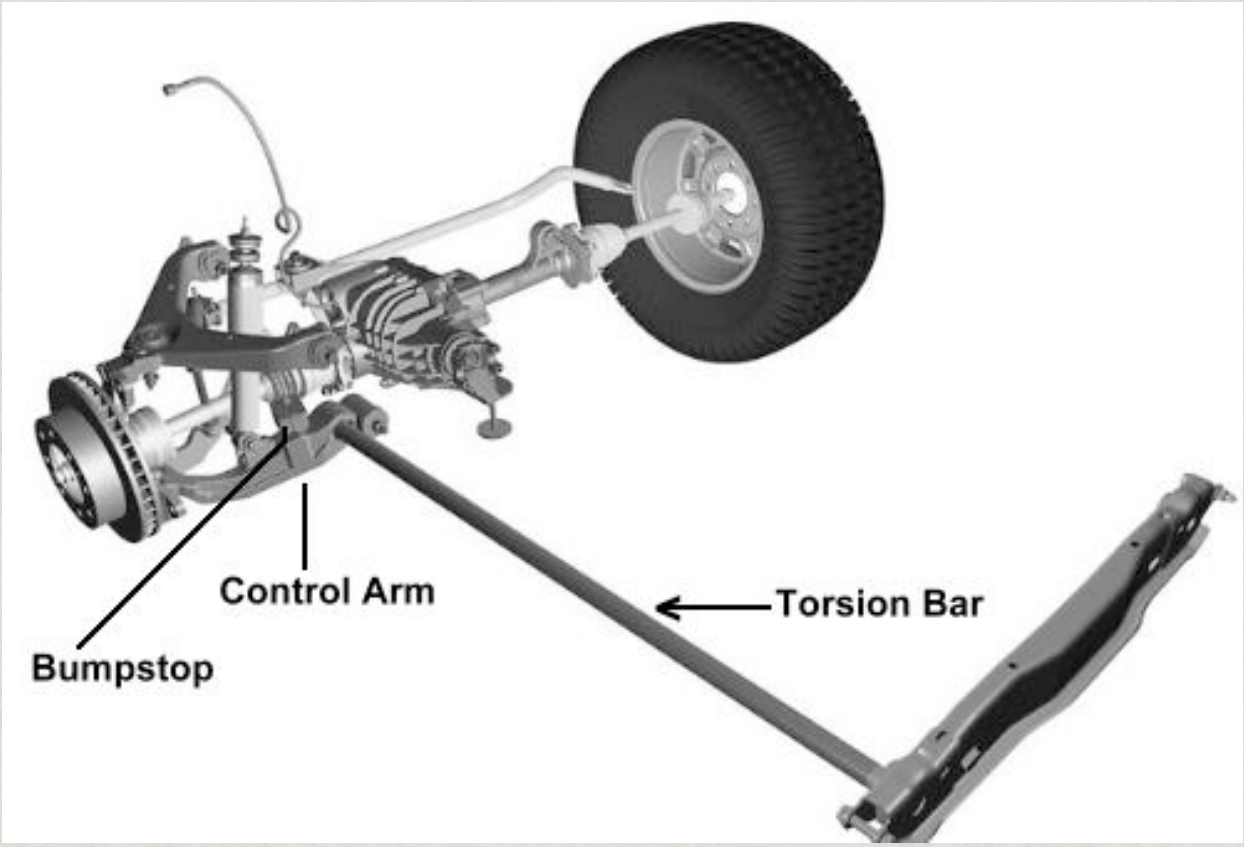
That is all you need to know.....

- A few degrees of front wheel caster (trail) makes your GMC go straight down the road. To much (over 5 degrees) will make it steer hard & may over stress the steering components. Caster must be the same on both sides!
- Front tires should be straight up and down (zero camber). Rear tires should be a bit tire top in (up to 2 degrees) but no more than that.
- All six tires should run parallel with the frame and with each other (zero toe) both front and rear.

There is one more thing

- Like Steve Jobs was famous for saying, there really is one more thing you need to know.....actually, two things
- Ride height front and rear is critical to proper alignment. The rear ride height influences the front ride height far more than you might imagine. If it is out of whack you may find you are transferring way too much weight to one corner of the front end. Not a good thing!
- If you jack up either end of a GMC it can take several miles of driving before your GMC settles into the ride height it will adopt going down the road. Change the ride height and you alter camber, caster and toe all three!

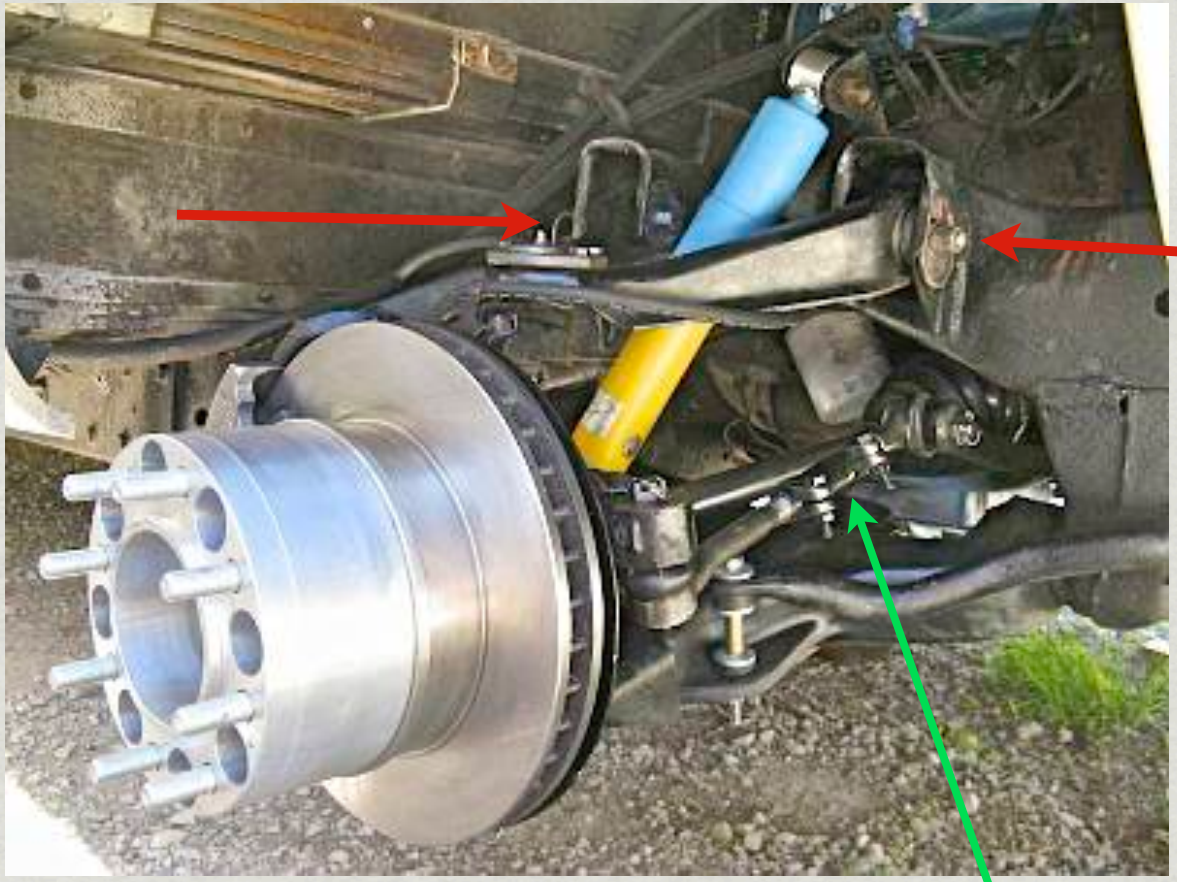
First, let's understand how our front suspension works - neither of these pics is of a GMC, but they are close enough to help us understand what is going on



CONTROL ARMS ARE ATTACHED TO THE FRAME AT FOUR PIVOT POINTS, GMCS OBVIOUSLY HAVE NO SPRING, JUST A TORSION BAR AS SHOWN AT LEFT

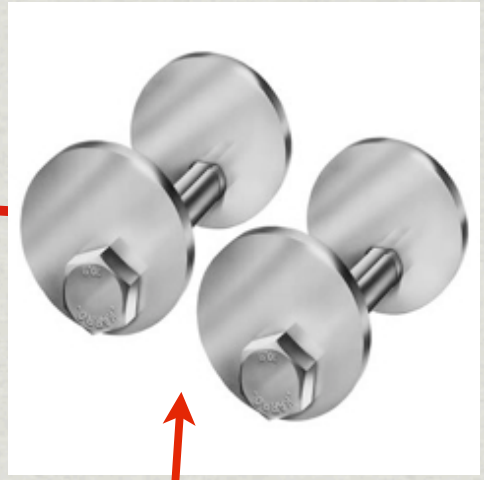
NOW LET'S LOOK AT AN ACTUAL GMC FRONT END, THIS IS A 1 TON CONVERSION.

ALL THE CAMBER AND CASTER ADJUSTMENTS ARE MADE BY MOVING THE UPPER CONTROL ARM PIVOT POINTS A LITTLE BIT IN OR OUT IN SLOTS CUT IN THE MOUNTING BRACKETS WELDED TO THE FRAME. AS THESE PIVOT POINTS MOVE, THE UPPER BALL JOINT MOVES IN RELATION TO THE LOWER BALL JOINT CAUSING A CHANGE IN CAMBER AND CASTOR. MOVING THE REAR PIVOT POINT MOSTLY EFFECT CASTER, MOVING THE FRONT PIVOT POINT MOSTLY EFFECTS CAMBER.



KAREN BRADLEY PHOTO

TOE IS ADJUSTED BY TURNING THIS SLEEVE



You may never have had a proper alignment on your GMC!

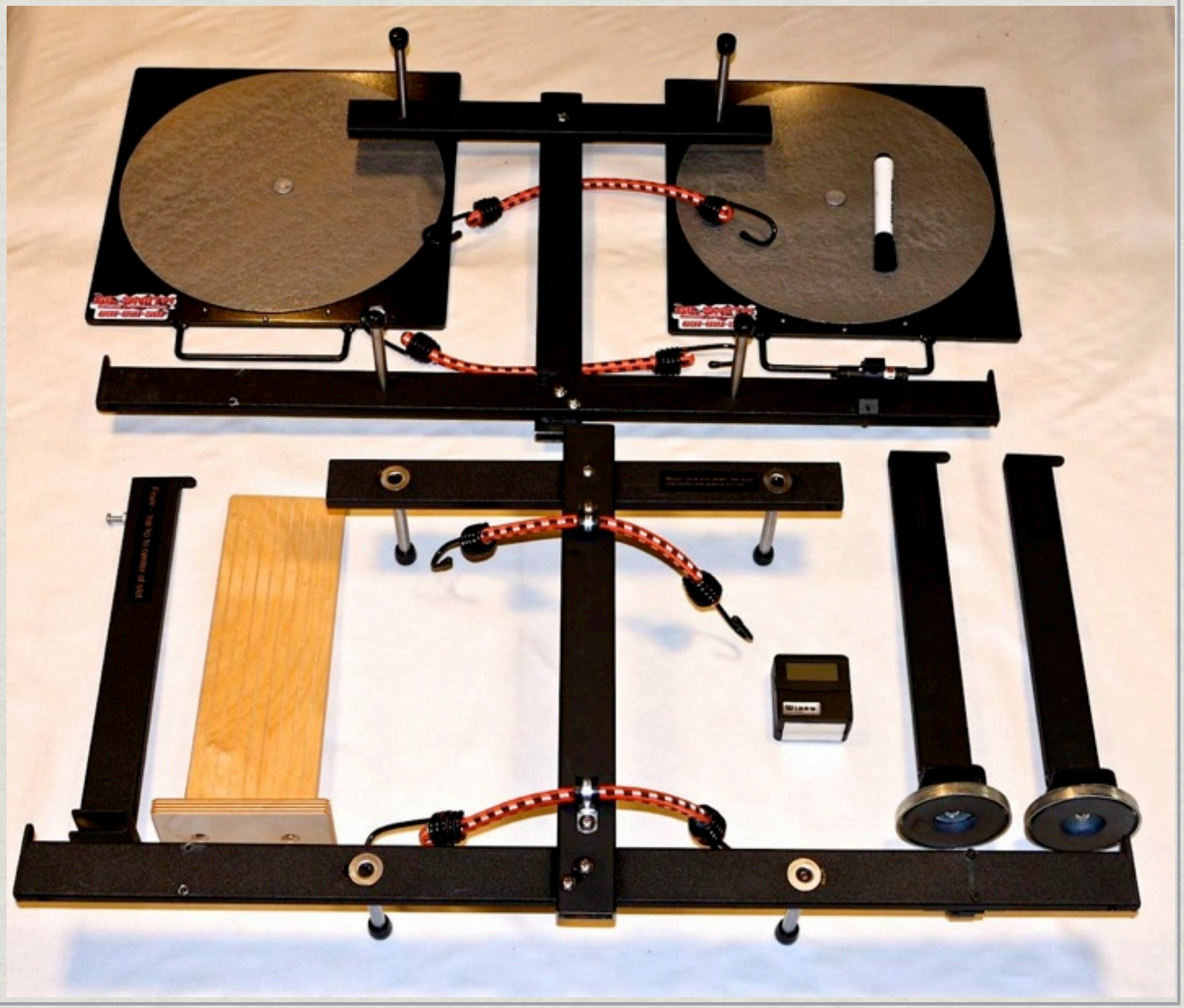
- Even the most experienced alignment people have little experience with a vehicle where both the front and rear ride height are adjustable.....
- and are seldom willing to take the time to drive your GMC two or three miles to settle the suspension each time they jack it up - as most do every time they make a camber or caster adjustment on either front wheel
- The good news is you can easily check their work or align it yourself right on your own parking pad

Over 90% of you came in here out of whack!

- 84% were low in the front on one or both sides
- 48% were high in the rear on one or both sides
- Only 8% were ok in two of the three measurements taken (two fronts and one rear)
- Of those half were low on one front and half were high in the one side of the rear we measured

HERE IS EVERYTHING YOU NEED TO DO A PROFESSIONAL ALIGNMENT

GMCWS HAS ONE OF THESE KITS AND MAY MAKE IT AVAILABLE TO YOU TO USE OR YOU CAN BUY OR MAKE ONE FOR YOURSELF



THE FIRST THING TO DO IS MEASURE REAR RIDE HEIGHT ON THE PASSENGER SIDE WHICH SHOULD BE 11 11/16” +-1/4” FROM TOP OF SLOT TO THE FLOOR

THE GO-NO/GO RIDE HEIGHT GAUGE PROVIDED IN THE KIT MAKES THAT REALLY EASY - IF THE SCREW FITS, YOU ARE AT PROPER RIDE HEIGHT. IF IT DOESN’T FIT, YOU ARE NOT.

THE SLOT IS BLOCKED ON THE DRIVERS SIDE TO MAKE ROOM FOR THE GENERATOR ON MOST COACHES.....

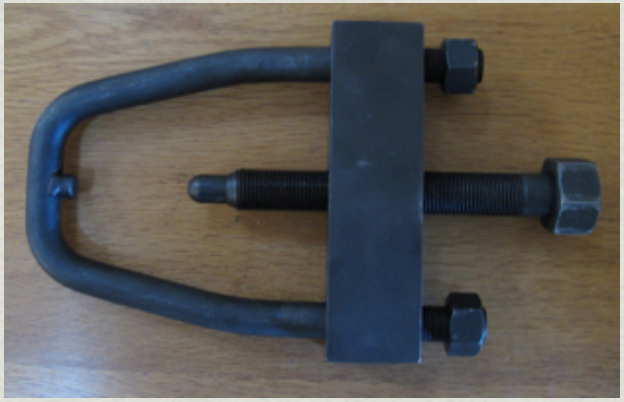
.....SO MEASURE FROM THE FLOOR TO A KNOWN POINT AND USE THAT TO CHECK THE DRIVER SIDE RIDE HEIGHT

ADD OR LET OUT AIR UNTIL THE RIDE HEIGHT IS CORRECT, THEN DRIVE THE COACH TO SETTLE THE SUSPENSION AND CHECK IT AGAIN - IT MAY TAKE TWO OR MORE TRIES TO GET IT RIGHT ON BOTH SIDES.

MEASURE FRONT RIDE HEIGHT. IT SHOULD BE 13 1/8" +- 1/4" FROM THE TOP OF THE SLOT TO THE FLOOR. THE SLOT IS JUST AHEAD OF WHERE THE FRONT CLIP BOLTS INTO THE FRAME RAILS. USE THE GO-NO/GO GAUGE FROM THE KIT TO MAKE THIS EASY

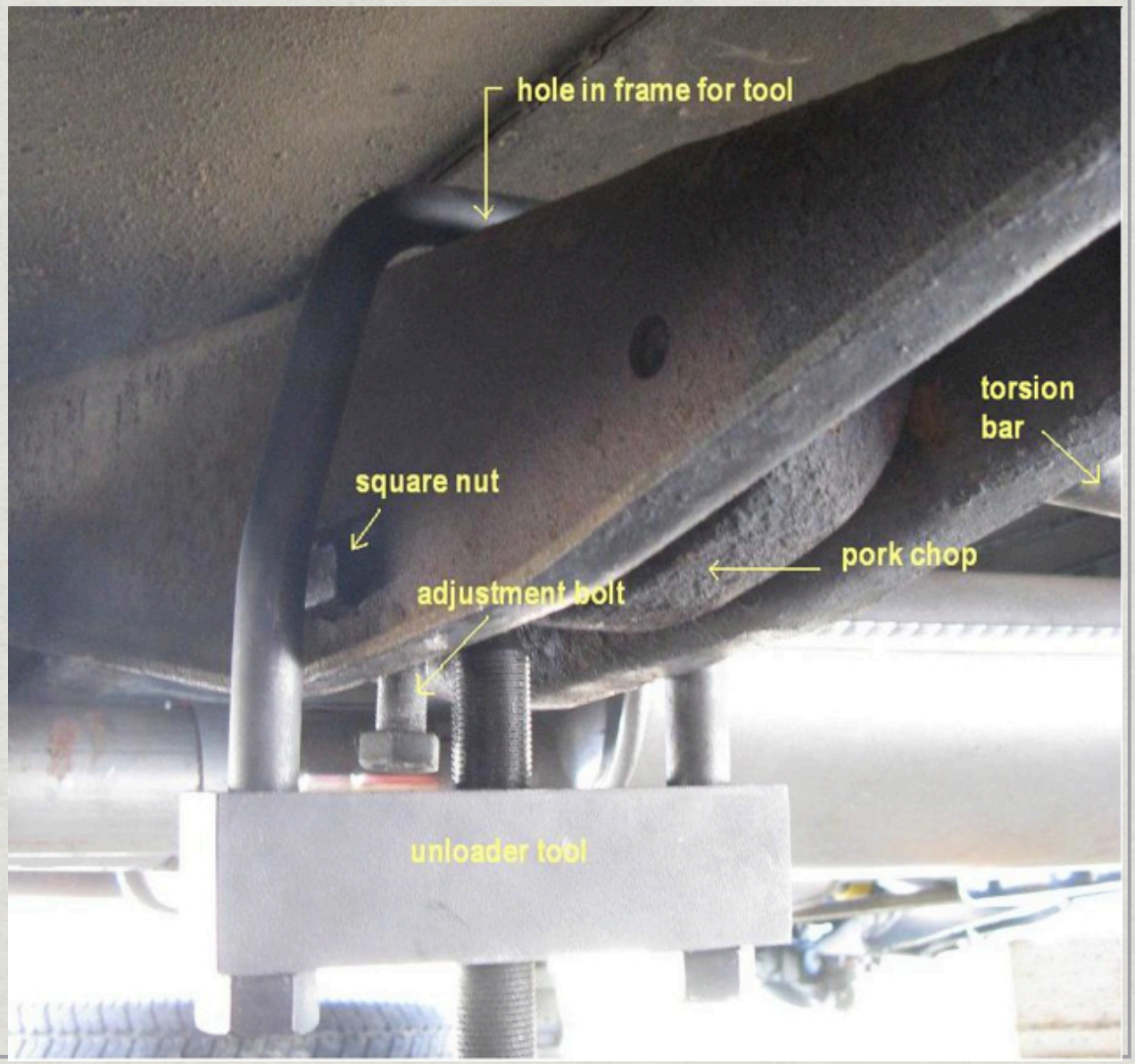
IF THE FRONT RIDE HEIGHT IS OFF, YOU CAN STILL MEASURE THE CAMBER, CASTER AND TOE, BUT THOSE MEASUREMENTS WILL BE MEANINGLESS BECAUSE THEY WILL ALL CHANGE ONCE YOU DO ESTABLISH THE CORRECT RIDE HEIGHT.

SETTING THE FRONT RIDE HEIGHT TAKES A SPECIAL TORSION BAR UNLOADING TOOL AND THE SKILL AND KNOWLEDGE TO SAFELY SUPPORT THE GMC WHILE JACKED UP. THIS IS A JOB BEST LEFT TO THOSE WITH THE PROPER TOOLS AND EXPERIENCE. IF YOU DO WANT TO DO IT, SAFELY SUPPORT THE COACH & UNLOAD THE TORSION BARS WITH THE SPECIAL TOOL. IT WILL TAKE ABOUT 4 TO 8 TURNS OF THE ADJUSTER BOLT TO CHANGE THE RIDE HEIGHT ABOUT ONE INCH.



KAREN BRADLEY PHOTOS

THIS IS WHAT THE SPECIAL TORSION BAR UNLOADING TOOL LOOKS LIKE AND HOW IT IS USED



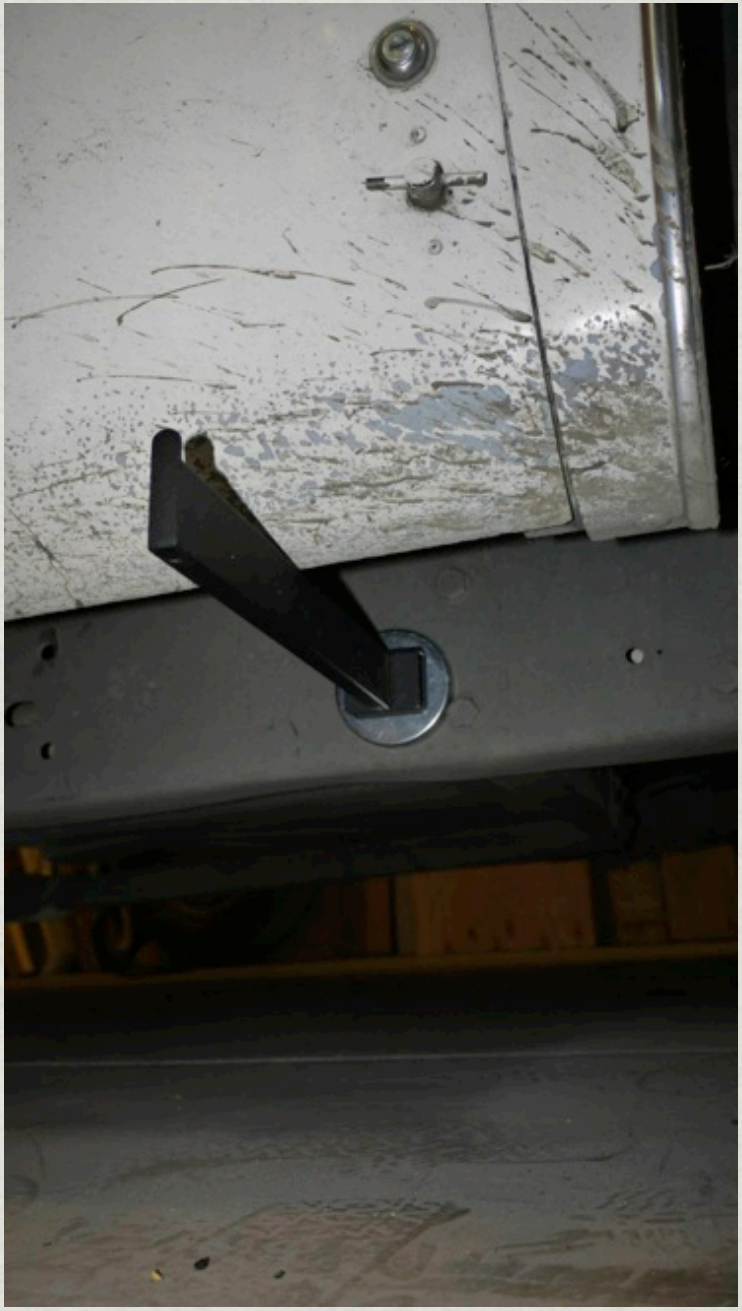
HERE IS WHY YOU MUST USE THE TORSION BAR UNLOADING TOOL BEFORE YOU ATTEMPT ANY FRONT RIDE HEIGHT ADJUSTMENT

NOTICE HOW FEW THREADS THERE ARE IN THE TORSION BAR ADJUSTER NUT BLOCK! TRY TO LIFT YOUR COACH JUST WITH THE ADJUSTER BOLT AND YOU ARE SURE TO STRIP THESE THREADS

PHOTOS FROM APPLIED GMC WEB SITE

ONCE YOUR RIDE HEIGHT IS SET CORRECTLY FRONT AND REAR, AND YOU HAVE DRIVEN YOUR COACH A FEW MILES TO SETTLE THE SUSPENSION, SET THE AIR PRESSURE CORRECTLY ON ALL SIX TIRES. NOW PUSH OR DRIVE THE COACH ONTO THE TURN PLATES. DO NOT JACK UP THE COACH!

ATTACH THE ALIGNMENT KIT STAND OFF PLATES WITH BUNGIE CORDS PROVIDED. THE ARMS WILL ALL BE CO-PLANAR WITH YOUR WHEEL.



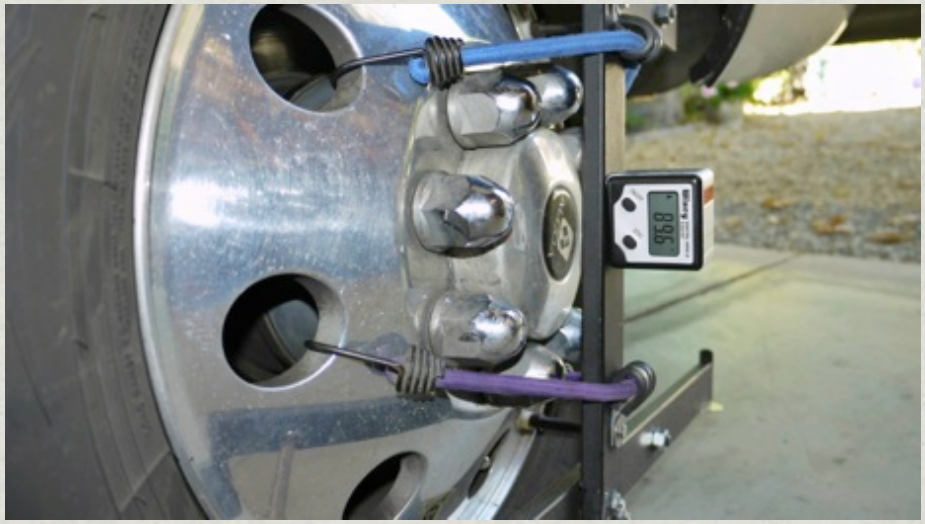
NEXT, ATTACH THE TWO MAGNETIC STAND-OFF ARMS TO THE FRAME, ONE FRONT NEAR THE SLOT AND ONE UNDER THE REAR COMPARTMENT DOOR. THESE WILL BE USED TO POSITION THE LASER TARGETS TO ALLOW YOU TO MEASURE FRAME PARALLELISM

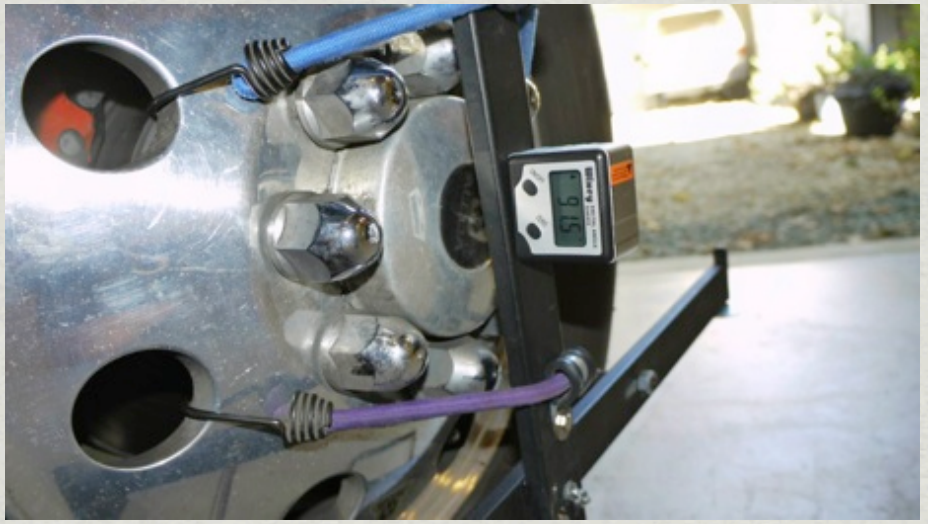
THERE IS A GUNSIGHT LASER MOUNTED TO THE STANDOFF FRAMES NOW MOUNTED ON THE WHEEL. IF YOU PUT A LASER TARGET ON THE END OF THE FRAME STANDOFF ARMS YOU CAN SEE WHERE THE LASER LIGHT HITS THE TARGET. IF THE LASER HITS THE TARGET IN THE SAME PLACE WHEN THE TARGET IS BOTH FORWARD AND REARWARD, THEN THE WHEEL MUST BE PARALLEL WITH THE FRAME.

ZERO THE DIGITAL ANGLE FINDER TO YOUR PARKING SLAB, THEN MAGNETICALLY ATTACH IT TO THE UPRIGHT ARM TO DETERMINE WHETHER YOUR WHEEL IS STANDING UPRIGHT (ZERO CAMBER) OR NOT

YOU NOW KNOW YOUR WHEEL IS STRAIGHT UP AND DOWN AND IS CO-PLANAR WITH THE FRAME SO IT IS TIME TO MEASURE THE CASTER ANGLE. MAKE A MARK ON THE TURN PLATE EVEN WITH THE CENTER REFERENCE. THE OTHER TWO REFERENCE POINTS ARE 20 DEGREES APART.

TURN THE WHEEL 20 DEGREES AND MEASURE CAMBER. TURN 20 DEGREES THE OTHER WAY AND MEASURE CAMBER AGAIN. THE ABSOLUTE DIFFERENCE MULTIPLIED BY 1.43 WILL BE THE CASTER ANGLE.





NOW YOU WANT TO CENTER THE STEERING MECHANISM. TURN THE STEERING WHEEL ALL THE WAY ONE WAY, THEN COUNT TURNS ALL THE WAY TO THE OTHER WAY, AND THEN TURN THE STEERING WHEEL BACK HALF THAT MANY TURNS. THE STEERING BOX IS NOW CENTERED.

THE STEERING WHEEL MAY OR MAY NOT BE CENTERED AT THIS POINT.

NOW LOOSEN THE TIE ROD PINCH BOLTS ON ONE WHEEL AND TURN THE SLEEVE TO BRING THAT WHEEL TO BE PARALLEL WITH THE FRAME WITH THE STEERING MECHANISM CENTERED. TIGHTEN THE PINCH BOLTS.

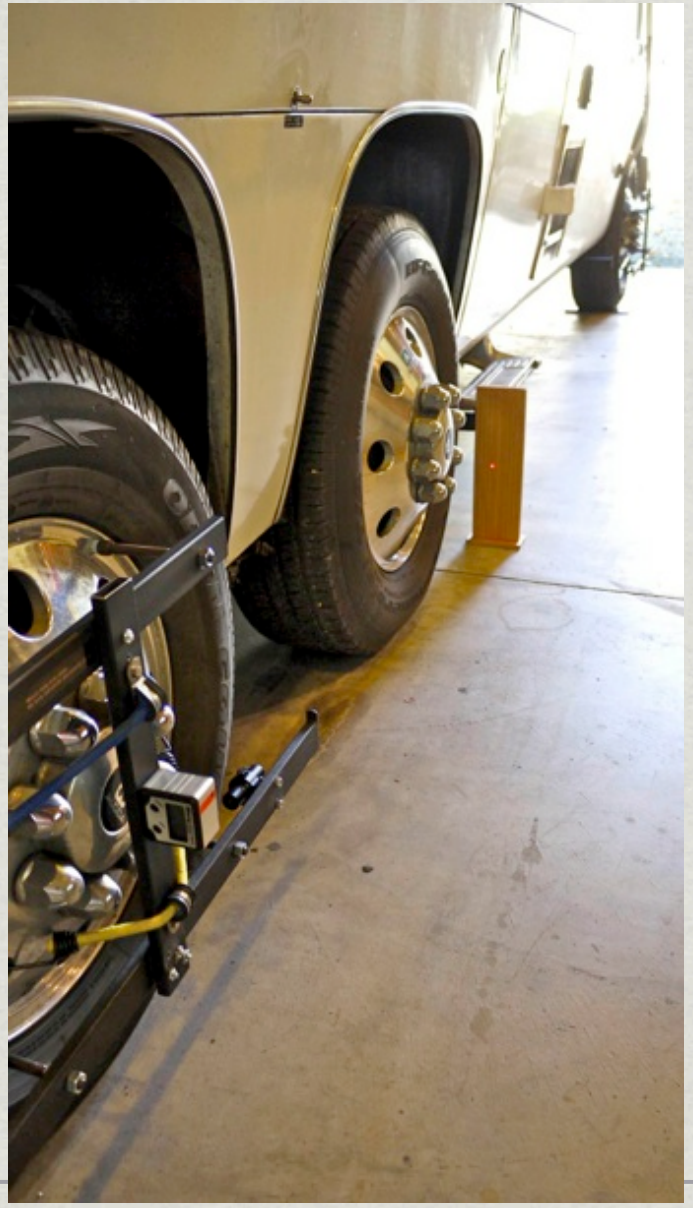
GO TO THE OTHER SIDE AND MOVE THE TIE ROD SLEEVE TO BRING THAT WHEEL TO ALSO BE PARALLEL WITH THE FRAME. THE WHEELS WILL BE AT ZERO TOE WHEN BOTH ARE PARALLEL WITH THE FRAME AND YOUR STEERING BOX WILL BE CENTERED. IF THE STEERING WHEEL STILL ISN'T CENTERED, EITHER MOVE IT ON THE COLUMN SHAFT OR INSTALL AN ADJUSTABLE DRAG LINK TO BRING THE WHEEL TO CENTER.

DOUBLE CHECK TOE BY MEASURING BETWEEN THE STAND OFF PLATE LOWER ARMS IN FRONT OF AND BEHIND THE FRONT WHEELS.

YOU WANT TOE TO BE ZERO.

IF THEY DON'T MEASURE THE SAME, THEN USE THE LASERS TO BRING ONE WHEEL TO FRAME PARALLEL. IT SHOULDN'T TAKE MUCH UNLESS SOMETHING IS BENT. LOOSEN THE PINCH BOLTS AND TURN THE SLEEVE ON THE TIE ROD ENDS ON THE WHEEL THAT IS NOT NOW PARALLEL WITH THE FRAME UNTIL TOE MEASURES ZERO. BOTH TIRES WILL NOW BE PARALLEL WITH THE FRAME AND EACH OTHER, AND YOUR STEERING BOX & WHEEL SHOULD BE NEARLY CENTERED.

NOW IT IS TIME TO CHECK THE FOUR BACK WHEELS. MOVE THE STAND OFF PLATES TO ONE REAR WHEEL AND USE THE LASER AND TARGET TO SEE HOW CLOSE THAT WHEEL IS TO BEING PARALLEL TO THE FRAME.



IT IS NOT UNCOMMON FOR ONE OR MORE OF THE REAR WHEELS TO BE SPLAYED IN OR OUT FROM BANGING AGAINST CURBS.

IF BOTH WHEELS ON A SIDE ARE OUT THE SAME AMOUNT THE WHOLE BOOGIE MOUNT CAN BE SHIMMED TO BRING THEM BACK INTO ALIGNMENT.

BUT, IF ONLY ONE IS OUT, THEN THE ARM IS BENT AND YOU WILL HAVE TO BEND IT BACK TO BRING THAT WHEEL BACK TO FRAME PARALLEL

USE THE DIGITAL ANGLE FINDER TO MEASURE CAMBER ON EACH OF THE REAR WHEELS AS WELL. YOU WANT 1 TO 2 DEGREES TIRE-TOP-IN CAMBER ON ALL FOUR

Now you know it all…

- You know camber, caster, toe and frame parallelism on both front wheels
- and camber and frame parallelism on all four rear wheels
- It took us quite a while to describe how, but once you have the ride height set correctly it will only take you 30 to 60 minutes to make all these very accurate measurements yourself right on your own parking slab here or at home

The payoff is huge

- With the ride height set correctly front and rear, all six wheels running parallel with the frame, caster set to as much as you can get up to +5 deg (even on both sides), front camber and toe set to zero and rear camber set to 1 to 2 degrees....
- Your coach will go down the road straight and true with no tendency to wander or get blown around in the wind. One finger on the wheel and a big grin on your face!
- and those expensive tires will last a lot longer to boot

Summary....

- Your coach is not a car, and certainly not a race car, so you must set everything to coach factory specs (compensating for radial tires) to get it to drive correctly.
- The specs are quite different from a Toronado for a number of very good reasons
- Ride heigh effects everything else so set that correctly first. It is not enough to just get it relatively the same, it must be at actual factory spec to be right, and over 90% of you drove in here with the ride hight incorrectly set!

Questions and comments from the floor.....

THIS IS MY "ALIGNMENT RACK"....THE COURTYARD OF OUR 1907 FORMER MASONIC TEMPLE BUILDING IN HISTORIC KERBY, OR