TECH INFO/UNDERSTANDING INDEPENDENT FRONT SUSPENSION

MUSTANG INDEPENDENT FRONT SUSPENSION. *The New Hot Set-Up! Hot Enough For You To Consider It For Your Car.*

Independent suspension can be very simple and very complicated at the same time. Success in making it simple is learning the rules. ***And it has it's own set of rules.*** Important, ***Rule #1***: Unlearn everything (almost) you know about steering and suspending a car with a solid axle and 4-link suspension. That would be like trying to play football using baseball rules.

The first thing to relearn is the action of the front axle and spindle during suspension travel. There are three things to control in the front wheel: camber, caster and toe angle.

CAMBER AND CASTER

In a solid axle the camber is built into the axle and the caster built into the 4-bar design. Both are constant (they don't change during suspension travel). A solid axle moves basically straight up and down therefore, so does the spindle.

On an IFS System, the upper and lower control arms, as well as the spindle and car chassis, form an uneven parallelogram, as viewed from the front (see fig. 1& 2). The spindle moves up and down in an arc-or radius-which is determined by the length and placement of the two control arms. Their placement also determines the amount of caster and camber change.

Important ***Rule #2***: If any of the four pivot points are moved in any direction, for any reasons, the spindle swings in a new, unique arc which is different from the old radius. Usually at the inner pivot of the upper arm on the Mustang suspension is the one to be moved. The control arm is usually shortened and the pivot shaft lowered to clear fenders on some cars (see Fig. #3). As you can see, the spindle will now swing in a new tighter radius. That in itself is not a problem. But, Please read on, as it is about to get real interesting.

TOE ANGLE

The paragraphs that follow explain why Heidt's Hot Rod Shop does not make Mustang Kits for certain cars.

As we mentioned, there are three things to control in the front wheel. Camber and caster we've already covered. The third is the toe, or steering angle at which the wheel is pointed, which determines where your car goes.

You can see that this means the spindle must always remain in the direction you have pointed no mater where the spindle is in the suspension travel. This is the job of

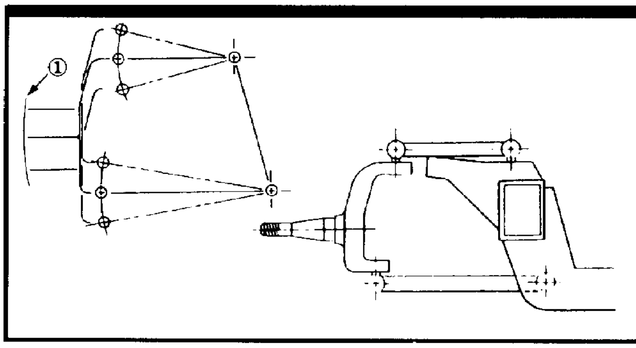


FIGURE 1
This is a correct Mustang II front suspension in a street rod, when the stock Mustang II suspension locations are used. Notice the parallel upper and lower arms. Also notice there is minimal camber change and almost flat radius (1) in the movement or the spindle during suspension travel.

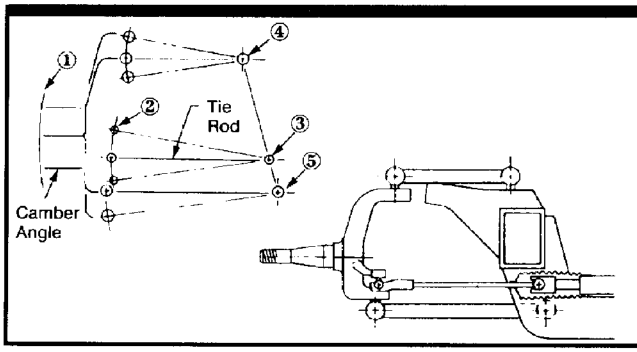


FIGURE 2
Now we have added the stock Mustang II steering rack in the stock Mustang II location using the stock Mustang II tie rod ends. Notice the radius of the rod ends (2) matches the radius of the spindle. Also, more importantly, see that the inner tie rod pivot (3) is ***IN LINE*** with the inner pivots (4) & (5) of the upper and lower arms. This is absolutely necessary. Ford Motor Co. did their homework.

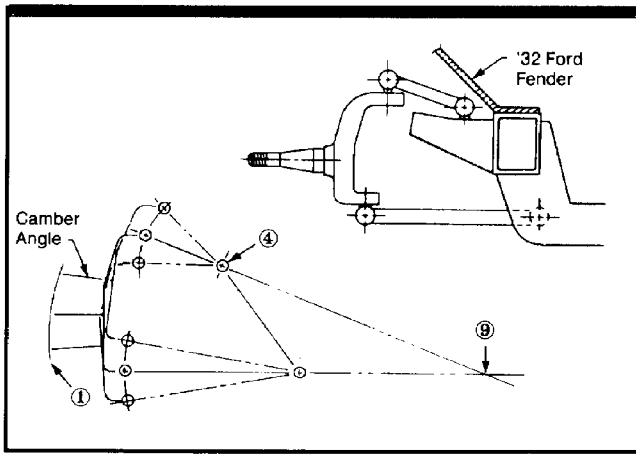


FIGURE 3
This is a typical "modified" Mustang II installation in a '32 Ford type car. The first change is to shorten and drop the upper arm pivot (4) to clear the fender. This causes the much sharper radius (1) of the spindle and resulting increased camber change. Also notice that the two arms now intersect at a theoretical point (9). But this alone is not the bad part. The next step will show you why.

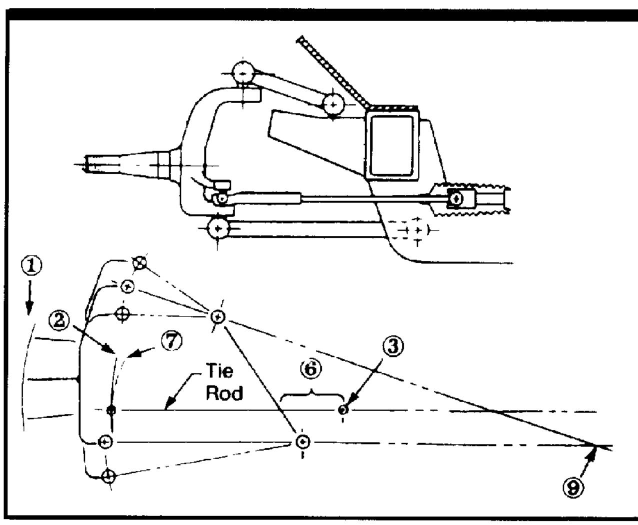


FIGURE 4
...it's all over by now. The other common modification/mistake is to widen the crossmember and use a long tie rod end. Ugh, as you can see, by adding the longer (incorrect) tie rod end, the inner pivot of the tie rod (3) now has been shifted way out of line by the dimension (6). Disaster! The flatter radius of the outer tie rod end (2) no longer matches the sharper spindle steering arm radius (7). This causes the spindle steering arm to follow the incorrect radius (2) and change steering angle, or "steer" as the suspension travels up and down over "bumps": more commonly known as "Bumpsteer". You can also see that the projected line from the tie rod does not intersect the intersection point (9) of the control arms. It should. This is why the only the MustangII system works correctly is the way Ford designed it, using all stock Mustang II parts, in the stock Mustang II locations.

the "Tie Rod". As you can see, the exact length and location of the inner pivot of the tie rod must be very carefully selected so the outer ends of the rod, which is attached to the spindle, swings in a radius which matches the spindle radius exactly. When designing a brand new suspension system on the drawing board this determaintion is very easy to make, since the tie rods on the rack are actually designed to match the control arm and spindle radius,. But on your conversion, this is where the problems start. So this is the next thing to unlearn.

When mounting a steering box in a solid axle installation, motor mounts, etc. usually dictate the location of the box and the pitman arm is modified to align the drag link with the tie rod. Selecting and installing a rack-and-pinion is nowhere near that simple or forgiving. ***When adapting an existing suspension design, such as the Mustang design, it is very important to keep every single mounting location and pivot point, including the rack, in their original designed places***. As you have just seen, the Mustang rack, with a specific tie rod length, was designed by Ford to match the swing radius of the Mustang spindle using stock length Mustang control arms ***in the locations which were selected when the Mustang was originally designed.***

If you shorten or lower the inner pivot of the upper arm, the spindle will now swing in a new, different radius which no longer matches the current tie rod radius. If you raise or lower the rack location, or change the tie rod length for any reason by using a longer tie rod end, the tie rod will swing in a new radius which does not match the current swing radius of the spindle (see Fig. #4).

EXPLAINING BUMPSTEER

The bottom line of all this radius explanation stuff is this: Since the tie rod ends attached to the spindle steering arm, the tie rod controls the steering angle of the front wheels. If your car goes over a "bump" the spindle goes up and down in its swing radius, determined by the upper and lower arms (remember?). If the tie rod swings in a different radius than the spindle during this suspension travel it will push or pull on the steering arm of the spindle, changing the direction of the front wheel, "steering" the car. And that is how the term and the monster "BUMPSTEER" were created, where 95% of the problems with incorrect suspension design are found. It is from people not really understanding ***this most important relationship between the tie rod length*** (not the overall rack length) ***and the spindle swing radius***.They feel that if they are able somehow with enough modifications to the parts, to "physically assemble all the parts" that it must be OK. Then they pull down the driveway, over that first curb and low and behold: BUMPSTEER. When you drive a car with

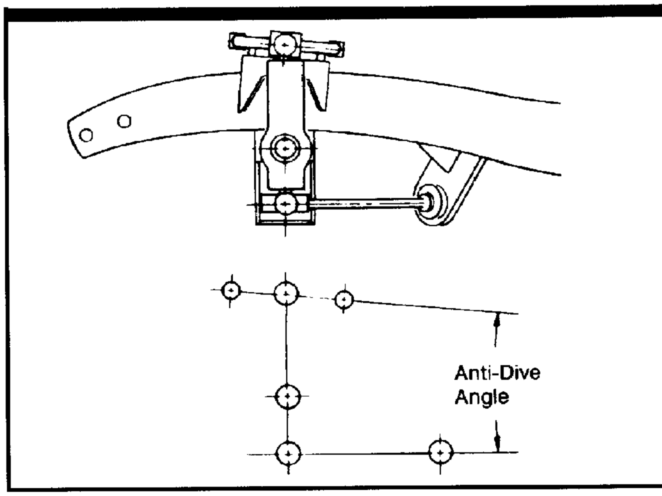


FIGURE 5
This is the side view of a correct Mustang IFS kit. Note the angle of the upper control arm, that is higher in front. This angle, through a lot of geometric forces in the spindle when braking, generates a lifting force on the frame at the inner A-arm mounts This is the same angle as the Pinto, which gives the same amount of anti-dive force as the Pinto. Simply put, factory designs work the way they are supposed to ın every respect, so why throw all their engineering and testing out the window?
This is the only way to incorporate this important feature, no matter what else you have heard. If you cannot see the angle in the upper arm, then the anti-dive is simply not there. Period.

BUMPSTEER, the car tends to wander or hop around as you drive down the road over bumps and dips. You have to constantly steer the car to keep it in the lane. Not what you would call an enjoyable ride.

BUILT-IN ANTI-DIVE

Anti dive is another characteristic required in an independent front suspension system. Anti-Dive helps prevent the car from "nose diving" under hard braking conditions, hence the name. It is something which is found in every factory car manufactured, including the Mustang and Pinto, visible in the suspension design in the upper control arm. It is mounted on an angle, with the FRONT pivot higher than the rear, not level ***(see fig. #5).***

The actual description of how anti-dive works involves extensive vector force diagrams and is much too lengthy to describe here. Let's just trust the big three auto manufacturers on this one, because they all use it. The Pinto uses a 3º angle for their anti-dive in the upper arm. It may look funny only because you are not used to seeing it on a street rod. Look at your family car. Do things look more normal now?

Don't bother looking for it on somebody else's street rod, especially one with other Mustang kits on it. They don't always know why the upper arms are "crooked" and fix(?) them. But how funny would your car look with the bottom of the grille ground away from bumping the street?

Now for the real point of this whole technical explanation. If you drive a Mustang or Pinto, you know that they don't bumpsteer. If you drive a car using a Heidt's Hot Rod Shop Mustang conversion kit you will happily find that it doesn't bumpsteer either. Why? Because we don't give you longer tie rod ends which would MISMATCH the tie rod length and it's swing radius with the spindle radius. Because we do not alter the thread width which would require athe longer tie rod ends. Because we don't move the location of the upper control arm pivot or shorten the upper arm (to clear fenders-that is why we limit our applications) which would change the spindle swing radius.

Because Heidt's Hot Rod Shop duplicates the design of the Mustang suspension system as Ford Motor Company designed it, you know it will work just as smoothly and effortlessly as it does in the Mustang, which is something no one else can claim. Study the diagrams and you will see for yourself why ***HEIDT'S HOT ROD SHOP*** manufacturers the finest Mustang Conversion Kit available. The only one which will truly make your car a pleasure to drive. The ***ONLY ONE*** that ***REALLY WORKS***!

Now that you have examined this technical book, wouldn't you rather purchase one of the most important parts of your car-the front suspension and steering system-from someone who genuinely knows and is able to tell and show you how and why it is supposed to work correctly?

It is important to us that you understand why we build the kits the way we do and have become the leader in Mustang front end conversion kits.

FOR MORE INFORMATION

For more technical information and even more detailed explanation of all the facts presented here, we recommend these books.

CHEVROLET POWER
Fifth edition
Published in 1984 by
General Motors

ADVANCED RACE CAR SUSPENSION DEVELOPMENT
By Steve Smith
Published By Steve Smith
Autosports Publication

MORE TECH INFO/INDEPENDENT FRONT SUSPENSIONS

SPRINGS, V-8 ENGINES & WEIGHT DISTRIBUTION "HEAVY" TOPICS.

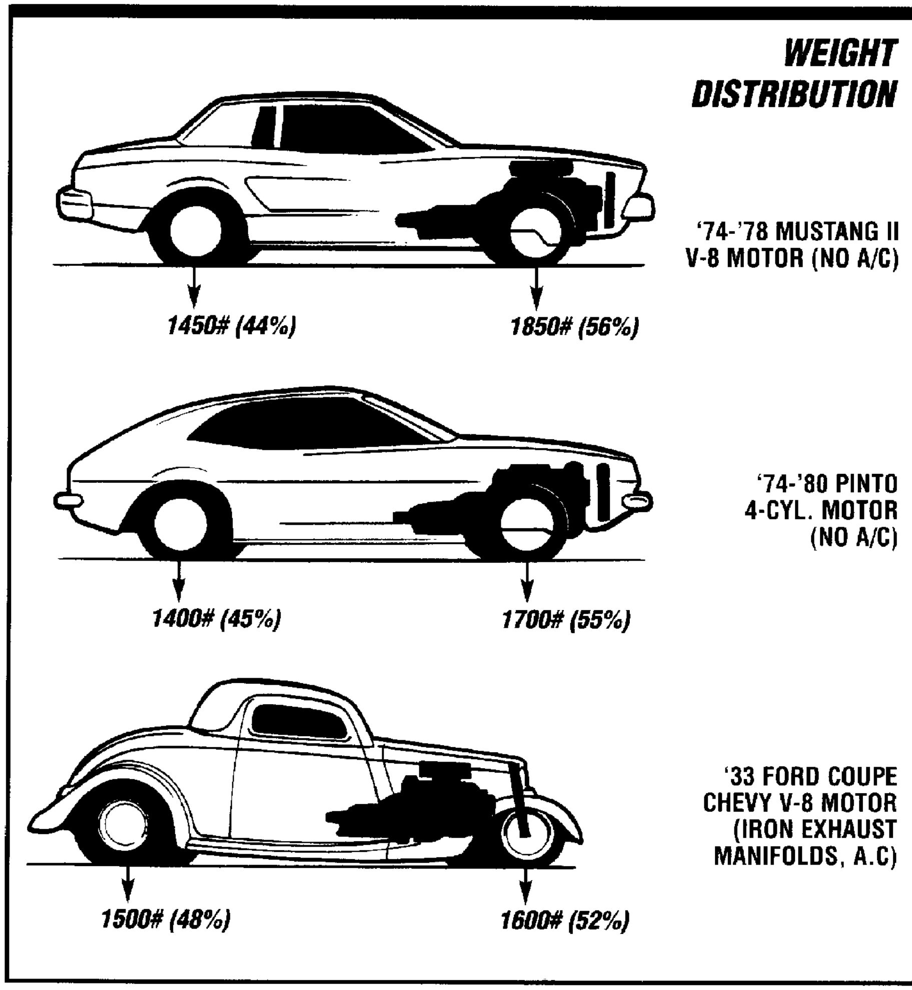
Weight Distribution. It is not how much your street rod weighs, but more importantly, it is how much the front end weighs compared to the back end. It can be expressed as a percentage, such as 55/45 where 55% of the total car weight is on the front wheels and and 45% on the rear wheels. Most late model cars are nose heavy, they are heaviest in front due to front engine placement. Remember in drag racing when guys figured out that if they moved the engine back in the car, they would change the "weight distribution" in the car. Moving the engine back or increasing "set-back" would decrease the weight on the front wheels and increase the weight on the rear wheels, where they needed the traction off the line. They changed the percentage difference, maybe going from a 55/45 to a 51/49 ratio. And as we all know, in racing, every little bit helps.

Ok, that all sounds great, and we can remember those days of drag racing, but what does all that racing info have to do with my street rod. I am building a nice '34 Ford 3-window street rod. I want it to ride super nice, so I even buy a Heidt's MUSTANG II independent front suspension, to get the best ride available. I am using the popular Chevy 350 engine, so I guess I nee the Mustang V-8 springs, right?

WRONG! We are about to be confronted with another of those pesky rules about independent suspension. The rule about weight distribution is about to ruin our super nice ride in our street rod. Take a look at the diagrams showing the 3 cars cars and their particular engine locations. Notice in the Mustang II and the Pinto the engine is very forward in the car. It is probably centered over the front wheels, with the radiator full of water and the battery all out in front of it. That stuff out in front of the axle center line actually creates a leverage/multiplication factor which puts a load on the front wheels (and springs!) that is more than just the weight of the components themselves. It is just like when you put the engine, or something else heavy, on the tailgate of a pick-up truck and it goes down. Then, as you move it up on the bed, the truck levels out.

Now look at the diagram of a typical '34 coupe street rod. Notice that the radiator is about centered on the front wheel centerline, the battery is probably either under the floor near the seat or in the trunk. Now how is that for "set-back." In drag racing, a couple of inches made a noticeable difference in the weight. In this case, which is typical to almost every street rod, we are talking about a 12 to 14 inch "set-back!" Again, we are not talking about a '34 Ford funny car, but a normal street rod with the engine in the normal location .

As you can see by the weights shown on the diagrams that the engine placement, and therefore the weight distribution of these tree cars yields some very interesting numbers. (These are weights of actual cars). You can see that the front end weight of a Mustang II with a V-8 engine is more than that of a street rod with a V-8. Even the Pinto, with its little 4-cylinder engine weighs more than the street rod on the front end.



Why? It is because of the engine location and the weight distribution. It really has very little to do with the total vehicle weight and type of engine.

Why are we discussing weight distribution and engine types? I just want a good ride. Well, the correct springs will give you a nice ride, and too stiff of springs will give a terrible ride, even if they are cut down. What we are trying to show here is that even though you have a V-8 engine in you street rod, the front end weighs less than the Pinto with its 4-cylinder engine. The springs in the 4-cylinder Pinto are almost always the correct choice for most street rods. Some late '40's cars may use a spring from a Pinto which had air conditioning, or may be a Pinto wagon. Springs only care about pounds, not pistons, and they don't care what they are holding up, only how much it weighs. We have never seen an application in a street rod which required the use of V-8 springs, even in late '40's cars with big blocks. They just don't weigh enough, compared to the Mustang II and it's forward mounted engine.

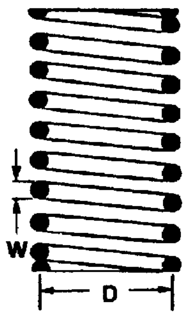
This brings up another point, or rule. As we mentioned before, it sometimes thought that cutting down a too stiff spring will be ok. Wrong again. It is true that you could cut enough off a V-8 spring, probably 3 or 4 coils, to get the suspension to come down to its correct designed position with the lower control arms level. But you would then have a spring that is stiffer than what you started with. So stiff, in fact, that you would think that someone welded all your ball joints together. If you look at the spring rate formula on the next page, you will see that by cutting the springs, you reducing the number of "free" or active coils, which actually increases the numerical spring rate. The spring rate is the stiffness of the springs and obviously as the numerical spring rate goes up, the ride quality goes down.

HEIDT'S Hot Rod Shop stocks the Pinto 4-cylinder springs which is the softest one available for their IFS Kits. We suggest you start with this spring in most applications. Or consult with a sales rep at HEIDT'S for your particular application. We want your HEIDT'S Mustang IFS to ride as smooth as it is designed to. This is how HEIDT'S reputation of the largest manufacturer of IFS Systems was earned. You can ride in comfort and confidence with HEIDT'S.

TAP DRILL SIZES

Tap Size	Threads Per In.	Drill Size	Tap Size	Threads Per In.	Drill Size
1/4	20	# 7	1/4	28	# 3
5/16	18	F	5/16	24	I
3/8	16	5/16	3/8	24	Q
7/16	14	U	7/16	20	25/64
1/2	13	27/64	1/2	20	29/64
9/16	12	31/64	9/16	18	33/64
5/8	11	17/32	5/8	18	37/64
11/16	11	19/32	11/16	16	5/8
3/4	10	21/32	3/4	16	11/16
13/16	10	23/32	7/8	14	13/16
7/8	9	49/64	1	14	15/16
15/16	9	53/64			
1	8	7/8			

STIFFNESS OF COIL SPRING

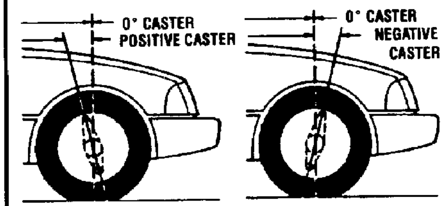


$$K = \frac{W^4 G}{8ND^3}$$

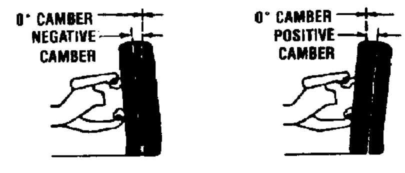
K-Spring rate (lb/in)
W-Diameter of spring wire (in.)
G-12,000,000 (for steel springs)
N-Number of "free" coils + 0.5
D- Diameter of spring coil (in.)

Note how sensitive the stiffness of the spring is to the diameter of the spring wire.

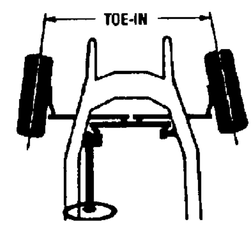
WHEEL ALIGNMENT



CASTER-The number of degrees of forward or backward tilt of the spindle at the top. Forward tilt of the spindle is negative caster. Backward tilt of the spindle at the top from true verticle is positive caster.



CAMBER-The number of degrees the top of the wheel is tilted inward or outward from true verticle. Inward tilt at the top of the wheel is negative camber. Outward tilt is positive camber.



TOE-IN-The distance in inches the leading edge of the front tires are closer than the trailing edge.

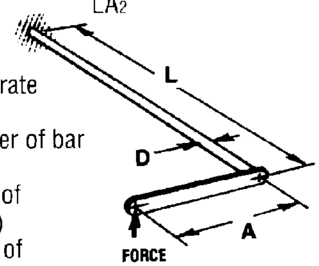
TORQUE SPECIFICATIONS

Normal Torque for Tightening Stud Nuts and Bolts
Stud or Bolt Tightening Torque

DIAMETER	IN. LBS	FT. LBS
1/4	55-85	4.5-7
5/16	110-165	9-14
3/8	190-285	16-24
7/16	295-445	25-37
1/2	450-680	38-57
9/16	640-970	53-81
5/8	880-1300	73-110

STIFFNESS OF TORSION BAR

$$K = 1{,}178{,}000 \frac{D^4}{LA^2}$$



K - Spring rate (lb/in.)
D - Diameter of bar (in.)
L - Length of bar (in.)
A - Length of lever arm (in.)

ENGINE SIZE

Engine size is measured by piston displacement. This is the total volume inches "swept" by all cylinders of the engine.

To determine the cubic inch displacement of an engine.

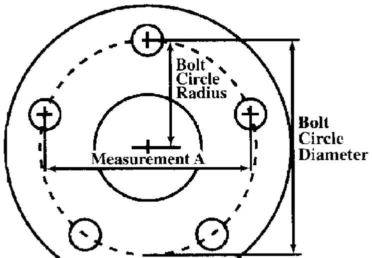
CID = Bore x Bore x Stroke x Number of Cylinders x 0.7854

SPEED CALCULATION

Many high-performance vehicles are capable of higher speed than their speedometer can register. If the vehicle is equipped with a tachometer, its speed can be estimated with the following formula.

$$MPH = \frac{\text{Overall Tire Diameter x Achieved Engine RPM}}{\text{Differential Ratio x Achieved Top Gear Ratio x 336}}$$

Bolt Pattern Dimensions for 5-lug Wheels



If Measurement A is:	Then your Bolt Circle is:
4 1/4 inches	4 1/2 inches
4 1/2 inches	4 3/4 inches
4 3/4 inches	5 inches
5 1/4 inches	5 1/2 inches

HANDY FORMULAS

Circumference of a circle: Multiply the diameter by 3.1416
Area of a circle: Multiply the diameter by itself and then by .7854
Volume of a cylinder: Find the area of the end then multiply by length
Area of the surface of a sphere: Multiply the diameter by itself and then by 3.1416
Volume of sphere: Multiply the diameter by itself and multiply this product by the diameter again. Then multiply this product (diameter cubed) by .5236
Area of a triangle: Multiply the base by the height and divide by 2.

CALCULATING PISTON DISPLACE

The area of head of the piston in square inches, times the number of inches in the stroke, times the number of cylinders, is the engine displacement in cubic inches. The formula is d2 x .7854 x L x N = Displacement in Cubic Inches. N is the number of cylinders.

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