Suspension 101

Modern suspensions are comprised of a spring, oil and a cartridge system to control damping. They offer a host of adjustments including spring preload which can be accomplished both manually by turning an adjuster ring directly on the spring, or they can be hydraulically controlled.

Additionally, these modern suspensions can have compression and rebound damping adjustments and adjustments to the length of a rear shock. Finally, more and more shocks are now offering both a high speed and low speed damping adjustment. Add in different spring rates, oil heights and oil viscosity (weight) along with riders of different sizes and abilities and you have a recipe for potential disaster in the hands of the unknowledgeable.

This will be a multi-part article to help you wade through your suspension, help you understand how it works and walk you through the steps on how to set up your bike's suspension. Once the initial setup is accomplished, additional time needs to be spent tweaking the suspension to help you understand how it works in real world applications. My preferred method of tweaking is to find a stretch of road with variables in road surfaces and terrain that I know like the back of my hand. Taking copious notes while spending several hours going back and forth on this stretch of road allows one to find the ideal settings for you and your bike and hopefully understanding suspension well enough to know if you need a change of spring rate, oil height adjustment and/or the help of a professional suspension tuner.

On the surface suspension seems pretty basic. Its primary job is to keep the tire in contact with the road surface. An imaginary motorcycle without suspension would have the motorcycle rise and fall over every bump. The faster the motorcycle moves, the more rapid this up and down movement becomes. Bumps hit at high speed can kick the motorcycle up pretty hard, but it can't return any faster than gravity will allow. The faster you go the more control you need with this up and down movement. Without it, your tire will end up spending more time in the air rather then on the road surface where you most need it.

Placing a spring between the tire and motorcycle is the first step in providing suspension. The problem is controlling the spring after it is compressed. The spring will apply equal pressure but now in the opposite direction. What you end up with is an undamped oscillator and you'll quickly find yourself bobbing up and down as you travel down the road. Likewise, in sudden maneuvers undamped suspension will cause the bike to wallow and dive. You need something to isolate this unwanted movement and help rid the spring of its stored energy. This is where damping comes in and no it's not called "dampening." Dampening is the act of wetting a rag … it has nothing to do with damping (modulating) suspension

Gratefully excerpted from a three-part article written by Chuck. For the complete article click here.

Progressive Suspension™ Notes

(Q) What is preload?

(A). Preload is used to set the suspension ride height (or sag) of the motorcycle. The motorcycle should sag about 20-25% of its total travel when the rider and passenger/load (if applicable) are on the bike. Not enough sag (too much preload) and the suspension will tend not to want to move initially, causing a rough ride over small obstacles such as stutter bumps. Too much sag (not enough preload) and the bike loses valuable travel, bottoming out easier and can cause stability problems. Any suspension (stock or aftermarket) can benefit from proper ride height adjustment. If a bike will not adjust to the proper sag after exhausting all adjustment settings, a different rate spring may have to be used.

(Q) What are spring rates?

(A) The rate of a spring is the amount of force necessary to compress the spring, usually measured in one inch increments. A straight rate spring will take the same amount of force for the entire travel of the spring. For example a 10 lb rated spring will take 10 lbs of force to compress it one inch, another 10 lbs (total 20) to compress it the second inch, and so on until the end of the spring travel. Now a progressive rate spring changes the force requirement as the spring is compressed. A 10-15 lb rated spring will require 10 lbs of force to compress the spring the first inch, another 12 lbs (total 22) to compress it the next inch all the way to the last inch where an additional 15 lbs of additional force is required to compress.

(Q) Why progressive rate?

(A) A progressive rate allows a plush, comfortable ride in the initial travel but since the rate shifts higher during compression, it can control the "diving" the bike wants to do under heavy braking or when you hit the big bump. A straight rate spring can't do it all like a progressive rate can because it is a compromise.

(Q) Why should I buy your 420 Single Shock?

(A) Our shocks are designed for the real world of street or dirt riding without the unneeded complexity of racing shocks. Our shocks are engineered and built to perform to a high level of excellence for many, many miles. And as a bonus, they perform without busting the budget by being value priced, sometimes hundreds of dollars less than the competition! Progressive offers true value for your hard earned dollars.

(Q) Why should I upgrade my suspension?

(A) Motorcycle manufacturers have a big job in choosing such things as suspension. They must consider many factors including cost, a soft and comfortable ride, various rider and load weights and a wide range of road conditions. In the final analysis manufacturers supply a suspension system to fit the "average rider," including road and load conditions.

(Q) Why do OEM shocks wear out so fast?

(A) Cost is a major consideration for manufacturers. Keeping within budget is mandatory and long term quality and life expectancy of high wear items such as shock absorbers and springs often suffer. Over stressed components such as internal valving parts, oil and springs are generally the first to wear out. The motorcycle manufacturers have to produce a product at an affordable price for the "average" rider. To achieve this some cost cutting must occur. Automotive manufacturers have the same problems, however, they offer optional suspension upgrade packages to improve handling, increase load capacity or offer adjustability. These options are expensive, sometimes costing several thousands of dollars but are quite popular because of the improvements they offer in handling stability and load capacity. Motorcycle manufactures do not offer these options so we must turn to quality aftermarket manufacturers for these improvements.

(Q) Why do I need aftermarket shocks?
(A) Most stock suspensions are setup for maximum plushness down the interstate, especially on touring motorcycles. However, this may cause problems when heavier loads are carried or more rugged and twisty roads are traveled. You're probably not "average." You may carry heavy loads, or pull a trailer (or sidecar) which taxes the stock suspension. Or you may just want a more controlled, stable ride, especially over rough or winding roads.

Gratefully excerpted from Progressive Suspension™ notes. For more reading click here. Please note we can order any Progressive Suspension™ Product available for your bike.

Suspension Troubleshooting

Here are some basic symptoms of suspension damping problems that you might find affecting your bike. Remember these are extreme examples; your symptoms may be more subtle. You may also have to find an acceptable compromise on either end of the adjustment spectrum. It all depends on how the bike's handling "feels" to you.

Lack of Rebound Damping (Fork)

- The fork offers a supremely plush ride, especially when riding straight up. When the pace picks up, however, the feeling of control is lost. The fork feels mushy, and traction "feel" is poor.
- After hitting bumps at speed, the front tire tends to chatter or bounce.
- When flicking the bike into a corner at speed, the front tire begins to chatter and lose traction. This translates into an unstable feel at the clip-ons.
- As speed increases and steering inputs become more aggressive, a lack of control begins to appear. Chassis attitude and pitch become a real problem, with the front end refusing to stabilize after the bike is counter steered hard into a turn.
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Too Much Rebound Damping (Fork)

- The ride is quite harsh--just the opposite of the plush feel of too little rebound. Rough pavement makes the fork feel as if it's locking up with stiction and harshness.
- Under hard acceleration exiting bumpy corners, the front end feels like it wants to "wiggle" or "tank slap." The tire feels as if it isn't staying in contact with the pavement when on the gas.
- The harsh, unforgiving ride makes the bike hard to control when riding through dips and rolling bumps at speed. The suspension's reluctance to maintain tire traction through these sections erodes rider confidence.

Lack of Compression Damping (Fork)

- Front end dive while on the brakes becomes excessive.
- The rear end of the motorcycle wants to "come around" when using the front brakes aggressively.
- The front suspension "bottoms out" with a solid hit under heavy braking and after hitting bumps.
- The front end has a mushy and semi-vague feeling--similar to lack of rebound damping.

Too Much Compression Damping (Fork)

- The ride is overly harsh, especially at the point when bumps and ripples are contacted by the front wheel.
- Bumps and ripples are felt directly; the initial "hit" is routed through the chassis instantly, with big bumps bouncing the tire off the pavement.
- The bike's ride height is affected negatively--the front end winds up riding too high in the corners.
- Brake dive is reduced drastically, though the chassis is upset significantly by bumps encountered during braking.

Lack of Rebound Damping (Rear Shock)

- The ride is plush at cruising speeds, but as the pace increases, the chassis begins to wallow and weave through bumpy corners.
- This causes poor traction over bumps under hard acceleration; the rear tire starts to chatter due to a lack of wheel control.
- There is excessive chassis pitch through large bumps and dips at speed and the rear end rebounds too quickly, upsetting the chassis with a pogo-stick action.

Too Much Rebound Damping (Rear Shock)

- This creates an uneven ride. The rear suspension compliance is poor and the "feel" is vague.
- Traction is poor over bumps during hard acceleration (due to lack of suspension compliance).
- The bike wants to run wide in corners since the rear end is "packing down"; this forces a nose-high chassis attitude, which slows down steering.
- The rear end wants to hop and skip when the throttle is chopped during aggressive corner entries.

Lack of Compression Damping (Rear Shock)

- There is too much rear end "squat" under acceleration; the bike wants to steer wide exiting corners (since the chassis is riding rear low/nose high).
- Hitting bumps at speed causes the rear to bottom out, which upsets the chassis.
- The chassis attitude is affected too much by large dips and G-outs.
- Steering and control become difficult due to excessive suspension movement.

Too Much Compression Damping (Rear Shock)

- The ride is harsh, though not quite as bad as too much rebound; the faster you go, the worse it gets, however.
- Harshness hurts rear tire traction over bumps, especially during deceleration. There's little rear end "squat" under acceleration.
- Medium to large bumps are felt directly through the chassis; when hit at speed, the rear end kicks up.

Gratefully excerpted from Sport Rider™. For more motorcycle suspension guides from Sport Rider™ click here.

Glossary of Suspension Terms

Bottoming (also called bottoming out)--when a suspension component reaches the end of its travel under compression. Bottoming is the opposite of topping out.

Cartridge Fork--a sophisticated type of fork that forces oil through bending shims mounted to the face of damping pistons contained within the fork body. The primary advantage of cartridge forks is they are less progressive than damping rod forks. The shims allow damping control at very low suspension speeds while high speeds deflect the shims more--causing less high-speed damping than fixed orifice damping rods. The resulting ride is firmer with less dive under braking while simultaneously lessening the amount of force square-edged bumps transfer to the chassis.

Compression Damping--controls the initial "bump stroke" of the suspension. As the wheel is forced upward by the bump, the compression circuit controls the speed at which the suspension compresses, helping to keep the spring from allowing an excessive amount of travel or bottoming of the suspension. Damping--viscous friction caused by forcing a fluid through some type of restriction. Damping force is determined by the speed of the fluid movement, not the distance of suspension travel.

Fork Oil Level--the level of oil within the fork as measured when fully compressed without the spring installed. It is used in tuning the amount of air contained inside the fork. Since compressing air makes it act as a spring, raising the oil level leaves less room for air, resulting in a rising rate throughout the fork's travel. Reducing the oil level reduces the force at the bottom, giving a more linear rate.

Packing--a phenomenon caused by excessive rebound damping. When a series of bumps, such as ripples, are encountered the suspension does not rebound completely between bumps and compresses (packs) further down on each successive bump. This can drastically change steering geometry if packing occurs on only one end of the motorcycle.

Preload--the distance a spring is compressed from its free length as it's installed with the suspension fully extended. Preload Adjuster--a method of adjusting suspension components' preload externally. These can be ramped or threaded.

Preload Spacer--material used to adjust a fork's preload internally. Typically, thin-walled aluminum or PVC tubing is used.

Rebound Damping--controls the extension of the fork or shock after it compresses over a bump--hence the term "rebound."

Ride Height--suspension adjustments (raising or lowering the fork or lengthening or shortening the shock) to alter the chassis attitude of the motorcycle.

Sag--the amount the front or rear of the bike compresses between fully topped out and fully loaded with a rider (and all of his riding gear) on board in the riding position. Sag can also affect steering geometry. Extra sag on the front end will decrease the effective steering head angle, quickening steering, while too little front sag will slow steering. However, too much front sag combined with too little rear sag could make the bike unstable.

Spring--a mechanical device, usually in the form of a coil that stores energy. When compressed, more energy is stored. Springs are position sensitive, caring only how much they have been compressed, not how quickly (as with damping).

Suspension Fluid--used inside a shock absorber to create damping when forced through orifices or valving. The fluid is also used for lubrication and should be incompressible.

Topping Out--occurs when the suspension extends to its limit. A shock with a spring of the proper rate mounted should have just enough force to top out without a rider on board.

Rake--the steering neck angle (not the fork angle) relative to vertical, which varies with changes in ride height. For example, the rake angle decreases when the front end compresses or is lowered. Changes in tire diameter can also influence rake by altering the ride height.

Trail--the horizontal distance between the front end's point of rotation (i.e. where a line drawn through the steering head would intersect the ground) and the contact patch of the tire. Since trail is dependent on rake, it is a variable dimension that changes proportionally with the variation of rake during suspension action. For example, trail drops off dramatically when the bike reaches full dive under braking, giving a rider more leverage to initiate steering inputs.

Unsprung Weight--the weight of every part of the motorcycle that is between the road and suspension (i.e. wheels, brakes, suspension components below the springs, etc.).

Valving--the mechanical hardware that creates damping. Valving is a combination of check valves, holes, ports, shims, springs, etc.

Suspension Tips
Adjust Your Rear Suspension Race Sag

Rear Suspension Race Sag is definitely the most important single adjustment affecting your bike's handling traits. Check this crucial adjustment monthly to insure it remains at your favorite setting. Race Sag is a measurement of how much the rear suspension sags under the riders weight compared to no weight on the bike.

- The first measurement is taken with the bike on a center stand with the rear wheel hanging freely in the air. Measure the distance between the rear axle and some convenient point near the fender like a seat bolt.
- The second measurement is taken with the bike on the ground and the rider standing straight up on the foot pegs supporting himself against a wall or tree. Again, me asure the distance between the same two points used above. (Standing increases the repeatability of this measurement.
- The Race Sag is the difference between the First and Second measurement. See the example below:

First Measure	24”
Second Measure	-- 20”
= Race Sag	4”

4” is a good starting point for most 125 thru 500cc MX Bikes

- To change the sag, use a long punch and a large hammer to loosen the spring locking nut on the shock. Then turn the preload nut to adjust rear spring preload. Note: Increasing spring preload will decrease Race Sag and vice versa.

- **One more hint.** Changing the Race Sage to 3 ¾" will raise the rear end making the bike turn sharper and reduce bottoming. Conversely changing the Sag to 4 ¼" will lower the rear and increase high speed stability.

Determining the Proper Rear Shock Spring Rate
Check your static sag to determine if you have the proper rear spring rate.

Having the proper spring rates in the front and rear is critical for proper handling. The spring rates must be selected to match the size of the bike and weight of the rider. Heavier riders require stiffer spring rates. A good approximation of your rear spring requirements can be found by measuring the rear suspension's static sag. This universally accepted measurement will quickly determine if your rear spring is approximately correct for your weight. Static Sag is a measurement of how much the bike sags under its own weight.

- Start by Setting the Race Sag as above.
- The first measurement is taken with the bike on a center. Stand with the rear wheel hanging freely in the air. Measure the distance between the rear axle and some convenient point near the fender like a seat bolt.
- The Second measurement is taken with the bike on the ground. Push up and down to allow the bike to find its natural resting position. Again, measure the distance between the same two points used above.
- The Static Sag is the difference between the First and Second measurement.

First measurement	24"
Second measurement	-- 23"
= Static Sag	1"

- If the static sag is less than 1/2 inch – the spring is definitely soft.
- If the static sag is greater than 1 3/4 inch – the spring is definitely stiff.
- Ideally the static sag will be between 3/4 and 1 1/2 inches.

Note: There is much confusion about the specifications above! Think of it this way. Before checking your static sag, you must first set your race sag to 4 inches. If you have a rear spring that is too soft, you will have to really crank down on the preload to get the 4 inches of race sag. You will be able to get 4 inches at some point, but you may have cranked in so much preload that without you on the bike, the additional spring preload will hold the bike up real high, maybe even topped out. If you are close to topped out, the static sag number will be – small under 1/2".

Many thanks to Rick Johnson, Too Tech Racing.

Sag Sheet			
	Model	Year	Mileage
Bike			
Owner			
	Make	Spring	
Rear shock			
Front springs			
FRONT	(top of fork tube to clamp)		
Ride height			
REAR	(typically not adjustable)		
Ride height			
Race Sag	4"		
Rear			
Front			
Static Sag	min 3/4" max 1 1/2"		
Rear			
Front			
Tire Pressure			
Rear			
Front			