Taking Measurements for Critical Damping Analysis

Motion ratio is the amount something moves for a given amount of tire contact patch movement. Spring motion ratio is the amount the spring compresses and extends for a given amount of movement of the tire contact patch. Shock motion ratio is the amount the shock compresses and extends for a given amount of movement of the tire contact patch. On a coil-over shock, the spring motion ratio and shock motion ratio are the same. The bar motion ratio is the amount the end of the bar moves for a given amount of movement of the tire contact patch. Before taking measurements, establish the suspension position (elevation) with reference to the chassis while the car is on the ground.

To measure motion ratio:

1. Place the car on stands. Disconnect and remove the wheel and tire, spring, shock and one end of the sway bar as necessary to allow free movement of the suspension.
2. Put a jack under a point that will represent tire contact patch movement. This point can be anything outboard of the lower ball joint. The brake rotor, hub or spindle will work as these items, ignoring camber change, move vertically the same as the tire contact patch. If it is a solid axle, put another jack under the same point on other side of the car.
3. Move the suspension up to ride height with reference to the chassis.
4. On the side being measured, move it up another inch with reference to the ground. If it is a solid axle, lower the other side one inch with reference to the ground.
5. Measure what would be the installed length of the spring, strut or shock if installed.
6. Measure a reference distance, perhaps from the ground, to the position of the end of the sway bar.
7. Lower the suspension on the side being measured by 2 inches with reference to the ground. If it is a solid axle, raise the other side two inchs with reference to the ground.
8. Re-measure what would be the installed length of spring, strut or shock if installed.
9. Re-measure the reference distance to the position of the end of the sway bar.
10. Divide the difference in spring, strut, shock or bar movement by 2". The resulting motion ratio is usually a fraction between 0.50 and 1.00.
11. Obviously, record results for each measurement on the data sheet.

Bar rate is generally a published figure. However, this figure does not tell us what the resulting effect will be at the wheel. Motion ratio, flex in the chassis and flex in the linkage leading from the bar to the suspension add up to reducing the effectiveness of the bar. Most often, given the bar rate and motion ratios, calculated rates do not equal measured rates. Therefore it is most accurate to measure the effectiveness of the bar at the wheel. This is called the wheel rate of the bar.

To measure wheel rate of the bar:

1. Place the car on stands. Disconnect and remove the spring as necessary to allow free movement of the suspension. Leave the sway bar fully connected.

2. Place a scale pad on a jack stand and elevate the suspension on one side of the car to approximate ride height with reference to the chassis. The other side will also rise because the sway bar is connected. Again, anywhere outboard of the lower ball joint is an acceptable location for picking up the load of the suspension as long as this point can support the forces to be applied.
3. Bind the other side suspension from further upward movement. A steel rod in place of the shock or even a properly located block of wood could be used.
4. Additional weight on the chassis may be required to keep the car from rising off the stands.
5. Using the jack, become familiar with the loads and amount of movement available as the bar is twisted.
6. Pre-load the bar slightly. Record the weight on the scale pad.
7. Take a reference measurement. This is best done with a dial indicator on the top of the scale pad. Alternatively, though not as accurate, one could take a measurement from the floor to the top of the scale pad.
8. Raise the scale pad one half of the expected maximum travel and record the weight on the scale pad.
9. Raise the scale pad to the maximum expected travel and again record the weight.
10. Calculate the wheel rate of the bar by dividing the difference in weight by the change in elevation of the scale pad.
11. Perform these measurements a couple of times to be sure of getting accurate and repeatable results.
12. Obviously, record the resulting wheel rate of the bar on the data sheet. Note that it may not be linear.

Corner weight is what is measured when the car is placed on scale pads. Un-sprung weight is the weight of the tire, wheel, spindle, rotor, caliper, etc. plus one half of the weight of anything that is connected to the chassis, such as control arm(s), strut, spring, shock, roll bar linkage, etc. Sprung weight is the difference between corner weight and un-sprung weight. Weighing each component of the suspension may be worthwhile and if it is already disassembled. However, it can also be weighed as an assembly on the car with a reasonable degree of accuracy.

To measure un-sprung weight:

1. Corner weight the car. Record the results.
2. Place the car on stands. Disconnect and/or remove the spring, shock, strut and sway bar. Replace tire and wheel on hub. Put a scale pad on a jack. Place a jack with a scale pad under the tire and elevate suspension to ride height with reference to the chassis. If it is a solid axle, raise other side of the axle to ride height with reference to the chassis.
3. Move the suspension up and down a bit to be sure there is no binding. Record the weight on the scale pad.
4. Weigh and record spring, shock, strut and bar linkage.
5. Add one half of the weight of these items to the measured suspension weight. This total is the un-sprung weight.
6. Subtract the un-sprung weight from the corner weight.
7. Obviously, record these weights on the data sheet.