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Choosing the correct spring rate for your vehicle.

From answering numerous questions that WORKS customers have posed and the countless conversations regarding suspension setup, we've come to realize that there is much misconception and misinformation surrounding the topic of spring rates in particular. The purpose of this paper is to offer a small glimpse of the thought that goes into properly determining the appropriate baseline spring rates for a track or road-going vehicle.

1. Suspension Frequency and Determining the Wheel Rate

The first step in choosing spring rates is to choose desired suspension frequencies for the front and the rear. Suspension frequency is defined as the undamped natural frequency of the body in ride. Below is the basic equation for suspension frequency, f:

$$f = \frac{1}{2\pi}\sqrt{\frac{WR}{SW}}$$

where…

WR = Wheel Rate
SW = Sprung Weight

For example, the desired suspension frequency for a road going EVO that sees occasional track use can be determined to be approximately 1.6Hz. In contrast, vehicles that are dedicated to track use may have a desired suspension frequency in the range of 2.0-2.5Hz. Generally, vehicles with aerodynamic aids (higher downforce) will require higher natural frequencies. Lower frequencies result in a softer suspension with more mechanical grip. However, the transient suspension response will be slower. Coming up with the optimal frequencies will depend on the type and efficiency of the vehicle's aerodynamic aids, among many other factors.

It should be noted that the front and rear frequencies are generally different so that the body's pitching motion is stalled rather than develop into harmonics. The frequency split should be chosen based on the car's desired use and real world testing and development -- which take into account the effects of damping (which will not be covered in this paper).

Rearranging the above equation and solving for the wheel rate, *WR* we have:

$$WR = SW \times (2\pi f)^2$$

2. <u>Finding the Motion Ratio</u>

The motion ratio is basically the distance the spring moves compared to the distance the wheel moves given the same "bump." We will choose to find the motion ratio (*MR*) around static ride height (since the motion ratio is generally not constant over full wheel travel).

To find the motion ratio, the following simple measurements can be made:

Measure the distance from the inner pivot point of the lower control arm to the centerline of the contact patch. Next, measure the distance from the pivot point of the lower control arm to the point at which the line projected from the centerline of the spring intersects the line to the center of the contact patch. Refer to the figure below:

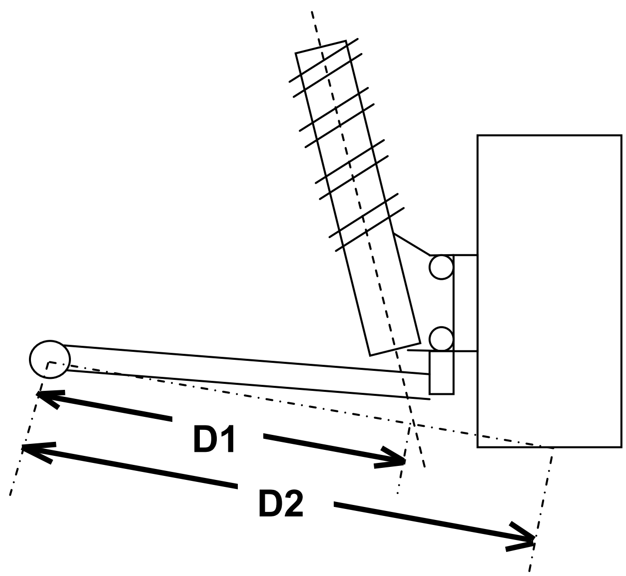

Figure 1. Finding the Motion Ratio

The motion ratio, *MR*, is simply the ratio of **D1** to **D2**.

Note: do NOT assume that a MacPherson strut suspension has a 1:1 motion ratio. A motion ratio of 0.98:1 or 1.02:1 is more typical.

3. <u>Calculating the Spring Rate</u>

Knowing the wheel rate, *WR*, and motion ratio, *MR*, we can calculate the desired spring rate for that particular corner of the vehicle:

$$\text{Spring rate} = WR \times MR^2$$

However, one must take into account the contribution of the strut to the effective spring rate. Thus, we have to calculate the motion ratio of the strut itself. To calculate the *MR* of the strut itself, measure the angle of inclination of the strut while the vehicle is at static ride height. This is not your camber or caster angle, it is the angle of the strut body itself.

The equation for the motion ratio, *MR*, of the strut is:

$$\left(1-\left(\frac{StrutAngle}{360}\right)\right)\times 100$$

This represents the percentage of the force from the spring that is translated into the force that contributes to the spring rate. For example, if by doing this calculation you come up with 98.6%, then that means only 98.6% of the spring force is contributing to the motion of the suspension. So you must add 1.4% to the final calculated spring rate.

Hopefully you have found this suspension information easy to understand and educational. Please stay tuned for more white papers published by WORKS in the future.

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