

Ride Quality & Ride Comfort

How ride is measured, what affects it, and quarter-car suspension simulation results

Key Concepts

Ride quality / comfort	How well a vehicle isolates occupants from road motion and vibration. The terms are interchangeable.
Objective metrics	Vertical acceleration measured or simulated, weighted per ISO 2631-1.
Subjective ratings	Trained evaluators score the ride; objective metrics are correlated to them.
Quarter-car model	One corner: sprung mass, unsprung mass, suspension spring + damper, tire spring + damper. Heave only.
Ride vs handling	Soft = comfort but more body motion (too soft → motion sickness). Stiff = control but harsh.

Key Numbers

4-8 Hz

Peak human sensitivity to vertical vibration (ISO 2631-1)

> ~1 Hz

Range ride quality is generally concerned with

25 m/s

Vehicle speed in the simulation

0.05 m

Road roughness amplitude R

Road Input Model

Road profile	$z_r(t) = R \sin(\omega t)$	Sinusoid with amplitude R (road roughness).
Velocity source	$v_r(t) = R \omega \cos(\omega t)$	Derivative of the road profile.
Excitation frequency	$\omega = 2\pi V / L$	V = forward speed, L = bump wavelength.
Normalized response	$\text{dB} = 20 \log_{10} [a_{ss} / (R \omega)]$	Steady-state sprung acceleration normalized as in the study.

Simulation Results

Case	Finding
At rest, flat road	Starts at -9.8 m/s^2 ; peak tire deflection $\approx -0.025 \text{ m}$; static deflection -0.015 m ; equilibrium $\approx 4 \text{ s}$.
Frequency response (L = 0.5-50 m, 12 runs)	Worst bumps at $\omega = 7.9 \text{ rad/s}$ (30 dB) and 78 rad/s (18 dB).
Tire stiffness -35% (775,660 → 504,179 N/m)	2nd peak $18 \rightarrow 16 \text{ dB}$; steady accel $\approx 2.5 \rightarrow 1 \text{ m/s}^2$; better above 30 rad/s .
+350 kg (5 × 70 kg)	1st peak $8.04 \rightarrow 6.88 \text{ rad/s}$; 2nd peak $18.03 \rightarrow 15.58 \text{ dB}$; steady accel $2 \rightarrow 1 \text{ m/s}^2$.

Lower magnitude and faster decay = better ride. Below $\omega \approx 1 \text{ rad/s}$ and above $\approx 100 \text{ rad/s}$ the ride is good; the 1-100 rad/s band is worst.

What Affects Ride Quality

Factor	Effect
Spring rate	Stiffer transmits more road input; softer isolates but allows more body motion.
Damping	Too little feels floaty; too much feels harsh.
Anti-roll bars	Control roll; stiff bars carry motion side to side on uneven roads.
Tires	Extra spring and damper between road and suspension.
Sprung / unsprung mass	Shifts natural frequencies and wheel response to bumps.
Seats & NVH	Seat foam filters vibration; noise, squeaks and rattles shape perceived comfort.

Trade-offs: lower tire pressure and added mass both improved ride in the model, but raise rolling resistance and hurt efficiency, acceleration and range. Keep tires at recommended pressure. Newey example: springs softened $\sim 200 \text{ lb/in}$ ($\approx 35 \text{ N/mm}$) for a bumpy circuit to keep tires in contact.