

Suspension Design Process

Customer needs → QFD → requirements cascade → interface analysis → trade-offs

Process: 1) Gather customer needs (clinics, surveys) → 2) Weight needs and build a QFD → 3) Cascade vehicle attributes into suspension requirements → 4) Map interfaces (diagram + matrix) → 5) Resolve trade-offs (cost, weight, durability, packaging).

Functions of a Suspension

- Support vehicle weight.
- Keep tires in contact with the road.
- Control direction of travel.
- Maintain correct wheel alignment.
- Reduce shock loads (springs, dampers, bushings).
- Maintain correct ride height.

Key Terms

Jounce / rebound	Upward suspension travel that compresses spring and damper / downward travel that extends them.
Spring types	Leaf, coil, torsion bar, air. Coil (e.g. MacPherson strut) is most common; air springs growing in premium vehicles.
Decomposition tree	Product → systems → subsystems → components, with requirements cascaded down to each level.
QFD	Quality Function Deployment. Customer needs weighted 1 (low) to 5 (high), related to engineering requirements with a direction of improvement, and benchmarked against competitors.
Requirements cascade	Table tracing each vehicle attribute and sub-attribute to specific suspension requirements.

Suspension Subsystems

Subsystem	Main function	Main components
Stabilizing bar	Reduce body roll	Sway bar (torsion bar)
Strut assembly	Maximize ride quality; reduce vertical acceleration to the cabin	Coil spring, shock absorber / strut
Knuckle & control arms	Enable steering; let chassis and wheels move together	Knuckle, control arms

Newey's Four Chassis Objectives

- **Consistent tire contact** through braking, cornering and acceleration.
- **Low weight:** every kilogram the tires carry costs performance.
- **Low aerodynamic drag** for acceleration, top speed and efficiency.
- **High, balanced downforce** front-to-rear through corner entry, mid and exit.

Customer Needs (example: MY2026 Toyota Sequoia, 68 surveyed)

Need	What customers want
Comfortable	Smooth, quiet ride that absorbs bumps and feels quick on its feet
Safety	No failure under braking; correct weight transfer in sharp corners
Performance	Enjoyable to drive without sacrificing comfort; reliable in all conditions
Reliable	Minimum service required
Cost	Low, affordable service and maintenance

QFD result: top functional specs were material selection, wheel size and service; lowest-impact were sprung weight, assembly process and towing.

Coil Spring Design Parameters

Mean coil diameter, D	Center-to-center distance of the wire across the coil.
Wire diameter, d	Diameter of the spring wire.
Pitch, p	Distance between successive coils on an uncompressed spring.
Active coils	Coils not touching the support.

Interface codes (diagram & matrix): P = physical · S = spatial / packaging · E = electrical · M = material flow · I = information flow · F = functional · 0 = no relationship

Trade-offs

- **Packaging:** body must also fit motors, wiring, seats; this limits suspension space.
- **Durability vs weight:** heavier materials hurt performance and mileage.
- **Cost:** lightweight high-strength materials are expensive.
- **Tires:** tire size and design act as a spring in series and change spring selection.
- **Friction:** coil-overs side-load the damper; torsion bars avoid it but cost packaging.