

Performance & Driveability Cheat Sheet

Tractive force, driving cycles and traction energy

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Tractive force	$F_t = m_v \frac{dv}{dt} + \frac{1}{2} \rho A C_d v^2 + \mu m_v g \cos \alpha + m_v g \sin \alpha$	Vehicle motion equation. Level road: last term is zero
Rolling resistance	$F_r = \mu m_v g$	Example: $0.012 \times 1,500 \text{ kg} \times 9.81 \approx 177 \text{ N}$
Traction energy	$E_{\text{trac}} = \int F_t v \, dt \, (F_t > 0)$	Positive tractive force only
Recuperable energy	$E_{\text{rec}} = \int F_t v \, dt \, (F_t < 0)$	Assumes perfect recuperation in the sample problem
Mean tractive force	$F = E_{\text{trac}} / \text{distance}$	Average energy per unit distance over a cycle
Check a drive mode	dv/dt from $v(t)$, then solve for F_t	Or compare the speed profile with the coasting solution each time step

Key takeaways

- **Performance** is measurable (acceleration, top speed, gradability, fuel economy). **Driveability** (drivability) is how smooth, predictable and comfortable the car feels in all conditions.
- Weight, power and drag set acceleration and top speed. Weight also hurts cornering because tires lose grip per unit of load as load rises.
- Tuning for peak performance (stiff springs, bars, lowered suspension) trades comfort and driveability for grip.
- Driving modes (Eco, Comfort, Sport, Track, etc.) reshape throttle, steering, shifting and suspension using the vehicle motion equation.
- Driving cycles are standardized speed-time patterns used to benchmark fuel economy and emissions on a chassis dynamometer.
- Aggressive driving can raise fuel use by 15–30% on highways and 10–40% in stop-and-go traffic.

Test cycles

Cycle	Region	What it represents
UDDS	US	Urban stop-and-go driving
HWFET	US	Highway fuel economy
NYCC	US	Dense low-speed city traffic
US06	US	Aggressive, high-speed supplemental cycle
NEDC (1997)	Europe	Older cycle, criticized as unrealistic
WLTP	Europe	Mandatory for new cars after Sept 2018