Understeer Gradient, Characteristic Speed and Steer Angle

Understeer gradient from axle loads and cornering stiffnesses, the characteristic (or critical) speed, and the front steer angle needed for a turn at a speed.

Method: Steady-state bicycle model

Input parameters

Unit system: SI

Parameter	Value	Unit
Vehicle mass	1,500.0	kg
Wheelbase	2.7000	m
CG to front axle	1.2000	m
Front axle cornering stiffness	90,000	
Rear axle cornering stiffness	100,000	
Speed	80.000	km/h
Turn radius	100.00	m

Calculated results

Parameter	Value	Unit
Front axle load	8.1722	kN
Understeer gradient	1.4567	°
Characteristic speed (understeer)	116.18	km/h
Lateral acceleration	0.50356	
Front steer angle	2.2805	°

Notes for this case

• K = W_f/C_αf − W_r/C_αr (rad per g; shown per g as an angle). δ = L/R + K·a_y/g. Understeer (K > 0): steer needed grows with speed, doubling the Ackermann angle at the characteristic speed √(gL/K). Oversteer (K < 0): the car becomes unstable above √(−gL/K). Cornering stiffness is per axle (both tyres), in N/rad.

Formula and method

$$K = \frac{W_f}{C_{\alpha f}} - \frac{W_r}{C_{\alpha r}}, \quad \delta = \frac{L}{R} + K\frac{a_y}{g}, \quad v_{ch} = \sqrt{\frac{gL}{K}}$$

Variables

m	Vehicle mass	kg
L	Wheelbase	m
a	CG to front axle	m
$C_{\alpha f}$	Front axle cornering stiffness	-
$C_{\alpha r}$	Rear axle cornering stiffness	-
v	Speed	m/s
R	Turn radius	m
W_f	Front axle load	N
K	Understeer gradient	rad
v_{ch}	Characteristic speed (understeer)	m/s
v_{cr}	Critical speed (oversteer)	m/s

a_y/g	Lateral acceleration	-
δ	Front steer angle	rad

Method and standards

Understeer.

Assumptions and limits

- Linear tyres; steady state; small angles.

References

Steady-state bicycle model

Report details

Report reference	FCC-S2EC-EH17 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/automotive/vehicle-dynamics/understeer-gradient

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.