Steering Axis Geometry: Scrub Radius and Caster Trail

Scrub radius at the ground and mechanical caster trail from kingpin inclination, caster angle and axis offsets at hub height, with the self-aligning moment.

Method: Steering axis geometry (projected)

Input parameters

Unit system: SI

Parameter	Value	Unit
Loaded tyre radius	310.00	mm
Kingpin (steering axis) inclination	13.000	°
Axis inboard of the wheel centre plane at hub height	85.000	mm
Caster angle	6.0000	°
Axis ahead of the wheel centre at hub height	0	mm
Lateral tyre force	4.0000	kN
Pneumatic trail	25.000	mm

Calculated results

Parameter	Value	Unit
Scrub radius (positive: axis meets ground inboard)	13.431	mm
Mechanical caster trail	32.582	mm
Total trail	57.582	mm
Self-aligning moment about the axis	230.33	N·m

Notes for this case

• Projecting the steering axis down to the ground: kingpin inclination σ moves it outboard by r·tan σ, so the scrub radius is r_s = d − r tan σ (negative when the axis meets the ground outside the contact centre, which stabilises braking on split friction). Caster ν moves the ground point forward by r·tan ν, giving the mechanical trail n = r tan ν + e (e negative when the axis passes behind the wheel centre, as with a motorcycle fork offset). The lateral force acts behind the contact centre by the pneumatic trail, so the aligning moment is F_y(n + t_p); this is small-angle geometry in side view and front view.

Formula and method

$$r_s = d - r\tan\sigma, \quad n_\tau = r\tan\nu + e, \quad M_z = F_y(n_\tau + t_p)$$

Variables

r	Loaded tyre radius	m
σ	Kingpin (steering axis) inclination	rad
d	Axis inboard of the wheel centre plane at hub height	m
ν	Caster angle	rad
e	Axis ahead of the wheel centre at hub height	m
F_y	Lateral tyre force	N
t_p	Pneumatic trail	m
r_s	Scrub radius (positive: axis meets ground inboard)	m
n_τ	Mechanical caster trail	m
$n_\tau + t_p$	Total trail	m
M_z	Self-aligning moment about the axis	N·m

Method and standards

Scrub and trail.

Assumptions and limits

- Small angles; projected views; rigid parts.

References

Steering axis geometry (projected)

Report details

Report reference	FCC-PRDM-7CMZ (the same inputs always give the same reference)
Generated	23 November 2026, 18:00 UTC
Calculator	Steering Axis Geometry: Scrub Radius and Caster Trail
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
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/steering-axis-scrub-trail

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.