Differential: Wheel Speeds and Spider Gear Speed in a Turn

Inner and outer driven wheel speeds in a turn from vehicle speed, turn radius and track, the carrier speed and the spider pinion speed relative to the carrier.

Method: Open bevel differential kinematics

Input parameters

Unit system: SI

Parameter	Value	Unit
Vehicle speed at the axle centre	30.000	km/h
Turn radius to axle centre	15.000	m
Track width	1,550.0	mm
Tyre dynamic radius	320.00	mm
Side gear teeth	16.000	
Spider pinion teeth	10.000	

Calculated results

Parameter	Value	Unit
Inner wheel speed	235.83	rpm
Outer wheel speed	261.53	rpm
Carrier speed	248.68	rpm
Spider pinion speed relative to carrier	20.558	rpm
Outer wheel extra travel per turn of 90°	2.4347	m

Notes for this case

• Wheels follow radii R ± t/2 at the same yaw rate, so n_o − n_i = v·t/(R·r_d). The open differential's carrier turns at the mean; each side gear turns (n_o − n_i)/2 relative to it, driving the spider pinions at that times z_s/z_p. In a 90° turn the outer wheel travels πt/2 farther than the inner.

Formula and method

$$n_{i,o} = \frac{v}{r_d}\frac{R \mp t/2}{R}, \quad n_c = \frac{n_i + n_o}{2}, \quad n_p = \frac{n_o - n_i}{2}\frac{z_s}{z_p}$$

Variables

v	Vehicle speed at the axle centre	m/s
R	Turn radius to axle centre	m
t	Track width	m
r_d	Tyre dynamic radius	m
z_s	Side gear teeth	-
z_p	Spider pinion teeth	-
n_i	Inner wheel speed	rad/s
n_o	Outer wheel speed	rad/s
n_c	Carrier speed	rad/s
n_p	Spider pinion speed relative to carrier	rad/s
Δs	Outer wheel extra travel per turn of 90°	m

Method and standards

Differential.

Assumptions and limits

- Steady turn, no tyre slip; open bevel differential.

References

Open bevel differential kinematics

Report details

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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/transmission/differential-wheel-speeds-turn

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.