

Important Steering System Formulas PDF



**Formulas
Examples
with Units**

List of 19 Important Steering System Formulas

1) Angles Related to Steering System Formulas

1.1) Ackermann Steering Angle at High Cornering Speed Formula

Formula

$$\delta_H = 57.3 \cdot \left(\frac{L}{R} \right) + (\alpha_{FW} - \alpha_{RW})$$

Example with Units

$$29 \text{ rad} = 57.3 \cdot \left(\frac{2700 \text{ mm}}{10000 \text{ mm}} \right) + (23.8 \text{ rad} - 10.271 \text{ rad})$$

Evaluate Formula

1.2) Ackermann Steering Angle at Low Speed Cornering Formula

Formula

$$\delta_S = \frac{L}{R}$$

Example with Units

$$0.27 \text{ rad} = \frac{2700 \text{ mm}}{10000 \text{ mm}}$$

Evaluate Formula

1.3) Caster Angle Formula

Formula

$$\Psi_c = \sin(C_1) \cdot \sin(C_2) \cdot (\cos(C_2) \cdot \cos(T_2) - \cos(C_1) \cdot \cos(T_1)) \cdot \frac{\tan(S)}{\cos(C_2) \cdot \sin(T_2) - \cos(C_1) \cdot \sin(T_1)}$$

Example with Units

$$0.0675 \text{ rad} = \sin(0.122 \text{ rad}) \cdot \sin(0.09 \text{ rad}) \cdot (\cos(0.09 \text{ rad}) \cdot \cos(0.165 \text{ rad}) - \cos(0.122 \text{ rad}) \cdot \cos(0.19 \text{ rad})) \cdot \frac{\tan(0.11 \text{ rad})}{\cos(0.09 \text{ rad}) \cdot \sin(0.165 \text{ rad}) - \cos(0.122 \text{ rad}) \cdot \sin(0.19 \text{ rad})}$$

1.4) Slip Angle at High Cornering Speed Formula

Formula

$$\alpha_s = \frac{F_y}{C_\alpha}$$

Example with Units

$$22 \text{ rad} = \frac{110 \text{ N}}{5}$$

Evaluate Formula

1.5) Steer Angle given Understeer Gradient Formula

Formula

$$\delta = \left(57.3 \cdot \left(\frac{L}{R} \right) \right) + (K \cdot A_\alpha)$$

Example with Units

$$15.8198 \text{ rad} = \left(57.3 \cdot \left(\frac{2700 \text{ mm}}{10000 \text{ mm}} \right) \right) + (0.218 \text{ rad} \cdot 1.6 \text{ m/s}^2)$$

Evaluate Formula

1.6) Vehicle Body Slip Angle at High Cornering Speed Formula

Formula

$$\beta = \frac{v}{V_t}$$

Example with Units

$$2 \text{ rad} = \frac{86 \text{ m/s}}{43 \text{ m/s}}$$

Evaluate Formula

2) Steering Parameters Formulas

2.1) Angle of Inside Lock given Turning Radius of Inner Front Wheel Formula

Formula

$$\theta_{in} = \text{asin} \left(\frac{L}{R_{IF} + \frac{a_{tw} \cdot c}{2}} \right)$$

Example with Units

$$0.7563 \text{ rad} = \text{asin} \left(\frac{2700 \text{ mm}}{3000 \text{ mm} + \frac{1999 \text{ mm} \cdot 130 \text{ mm}}{2}} \right)$$

Evaluate Formula

2.2) Angle of Inside Lock given Turning Radius of Inner Rear Wheel Formula

Formula

$$\theta_{in} = \text{atan} \left(\frac{L}{R_{IR} + \frac{a_{tw} \cdot c}{2}} \right)$$

Example with Units

$$0.7506 \text{ rad} = \text{atan} \left(\frac{2700 \text{ mm}}{1960 \text{ mm} + \frac{1999 \text{ mm} \cdot 130 \text{ mm}}{2}} \right)$$

Evaluate Formula



2.3) Angle of Inside Wheel Lock Satisfying Correct Steering Condition Formula

Formula

$$\theta_{in} = \text{acot} \left(\cot(\theta_{out}) \cdot \frac{c}{L} \right)$$

Example with Units

$$0.75 \text{ rad} = \text{acot} \left(\cot(0.728157 \text{ rad}) \cdot \frac{130 \text{ mm}}{2700 \text{ mm}} \right)$$

[Evaluate Formula !\[\]\(339a16584d5da0f0a3ca4e9ec17bf6a1_img.jpg\)](#)

2.4) Angle of Outside Lock given Turning Radius of Outer Front Wheel Formula

Formula

$$\theta_{out} = \text{asin} \left(\frac{L}{R_{OF} \cdot \frac{a_{tw} \cdot c}{2}} \right)$$

Example with Units

$$0.7285 \text{ rad} = \text{asin} \left(\frac{2700 \text{ mm}}{4990 \text{ mm} \cdot \frac{1999 \text{ mm} \cdot 130 \text{ mm}}{2}} \right)$$

[Evaluate Formula !\[\]\(6a9b39b98eb945faa14c645ec99e4eaa_img.jpg\)](#)

2.5) Angle of Outside Lock given Turning Radius of Outer Rear Wheel Formula

Formula

$$\theta_{out} = \text{atan} \left(\frac{L}{R_{OR} \cdot \frac{a_{tw} \cdot c}{2}} \right)$$

Example with Units

$$0.7286 \text{ rad} = \text{atan} \left(\frac{2700 \text{ mm}}{3960 \text{ mm} \cdot \frac{1999 \text{ mm} \cdot 130 \text{ mm}}{2}} \right)$$

[Evaluate Formula !\[\]\(eabd9f9ababee93effadc3b380fe65fd_img.jpg\)](#)

2.6) Angle of Outside Wheel Lock Satisfying Correct Steering Condition Formula

Formula

$$\theta_{out} = \text{acot} \left(\cot(\theta_{in}) + \frac{c}{L} \right)$$

Example with Units

$$0.7282 \text{ rad} = \text{acot} \left(\cot(0.75 \text{ rad}) + \frac{130 \text{ mm}}{2700 \text{ mm}} \right)$$

[Evaluate Formula !\[\]\(a8ff699ced33317c53c86f9bf3171905_img.jpg\)](#)

2.7) Mechanical Trail Formula

Formula

$$T_m = \frac{R_f \cdot \sin(\alpha_f) \cdot d}{\cos(\alpha_r)}$$

Example with Units

$$84.6724 \text{ mm} = \frac{600 \text{ mm} \cdot \sin(0.16 \text{ rad}) \cdot 12 \text{ mm}}{\cos(0.16 \text{ rad})}$$

[Evaluate Formula !\[\]\(1adebd97b172010e8ebc985144647a7c_img.jpg\)](#)

2.8) Motion Ratio or Installation Ratio in Suspension Formula

Formula

$$\text{M.R.} = \frac{ST}{WT}$$

Example with Units

$$0.65 = \frac{65 \text{ mm}}{100 \text{ mm}}$$

[Evaluate Formula !\[\]\(7fc7a78d681c65e5eab75b70bb438816_img.jpg\)](#)

2.9) Pinion Pitch Circle Radius Formula

Formula

$$R_p = \frac{t \cdot p}{2 \cdot \pi}$$

Example with Units

$$10.5042 \text{ mm} = \frac{6 \cdot 11 \text{ mm}}{2 \cdot 3.1416}$$

[Evaluate Formula !\[\]\(3f95af55ae28ab037601216bb535c135_img.jpg\)](#)

2.10) Steering Ratio Formula

Formula

$$S_r = \frac{R_{sw}}{R_p}$$

Example with Units

$$64 = \frac{672 \text{ mm}}{10.50 \text{ mm}}$$

[Evaluate Formula !\[\]\(cb0139fc6b99f4e83284e5bc4d164ede_img.jpg\)](#)

2.11) Torque Acting on Steering Arm Formula

Formula

$$\tau = F_f \cdot R_s$$

Example with Units

$$45 \text{ N} \cdot \text{m} = 150 \text{ N} \cdot 300 \text{ mm}$$

[Evaluate Formula !\[\]\(0ef696eb9e4ba374475390f46d57fd19_img.jpg\)](#)

2.12) Understeer Gradient Formula

Formula

$$K = \left(\frac{F_{zf}}{g \cdot C_{af}} \right) \cdot \left(\frac{F_{zr}}{g \cdot C_{ar}} \right)$$

Example with Units

$$0.2187 \text{ rad} = \left(\frac{9000 \text{ N}}{9.8 \text{ m/s}^2 \cdot 40 \text{ N}} \right) \cdot \left(\frac{7800 \text{ N}}{9.8 \text{ m/s}^2 \cdot 35 \text{ N}} \right)$$

[Evaluate Formula !\[\]\(3c2736615258f1842e1ca0abff6e5a69_img.jpg\)](#)

2.13) Understeer Increment due to Steering System Compliance Formula

Formula

$$K_{strg} = \frac{W_f \cdot (R \cdot \psi_c + t_p)}{K_{ss}}$$

Example with Units

$$0.2822 \text{ rad} = \frac{1000 \text{ N} \cdot (10000 \text{ mm} \cdot 0.067547 \text{ rad} + 30 \text{ mm})}{2500 \text{ N} \cdot \text{m}}$$

[Evaluate Formula !\[\]\(8a8109004b697fb7ea85fbbc18357422_img.jpg\)](#)



Variables used in list of Steering System Formulas above

- a_{tw}** Track Width of Vehicle (Millimeter)
- A₀** Horizontal Lateral Acceleration (Meter per Square Second)
- c** Distance between Front Wheel Pivot Center (Millimeter)
- C₁** Camber 1 (Radian)
- C₂** Camber 2 (Radian)
- C_{af}** Cornering Stiffness of Front Wheels (Newton)
- C_a** Cornering Stiffness
- C_{ar}** Cornering Stiffness of Rear Wheels (Newton)
- d** Triple Clamp Offset (Millimeter)
- F_f** Frictional Force (Newton)
- F_y** Cornering Force (Newton)
- F_{zf}** Load on Front Axle at High Speed Cornering (Newton)
- F_{zr}** Load on Rear Axle at High Speed Cornering (Newton)
- g** Acceleration due to Gravity (Meter per Square Second)
- K** Understeer Gradient (Radian)
- K_{ss}** Effective Stiffness of Steering System (Newton Meter)
- K_{strg}** Under Steer Increment due to Steering Compliance (Radian)
- L** Wheelbase of Vehicle (Millimeter)
- M.R.** Motion Ratio in Suspension
- p** Linear or Circular Pitch (Millimeter)
- R** Radius of Turn (Millimeter)
- R_f** Front Tire Radius (Millimeter)
- R_{IF}** Turning Radius of Inner Front Wheel (Millimeter)
- R_{IR}** Turning Radius of Rear Inner Wheel (Millimeter)
- R_{OF}** Turning Radius of Outer Front Wheel (Millimeter)
- R_{OR}** Turning Radius of Outer Rear Wheel (Millimeter)
- R_p** Pinion Pitch Circle Radius (Millimeter)
- R_s** Scrub Radius (Millimeter)
- R_{sw}** Steering Wheel Radius (Millimeter)
- S** Steering Axis Inclination (Radian)
- S_r** Steering Ratio
- ST** Spring or Shock Travel (Millimeter)
- t** Number of Pinion Teeth
- T₁** Toe Angle 1 (Radian)
- T₂** Toe Angle 2 (Radian)
- T_m** Trail (Millimeter)
- t_p** Pneumatic Trail of Tire (Millimeter)
- v** Lateral Velocity Component (Meter per Second)
- v_t** Total Velocity (Meter per Second)
- W_f** Weight under Front Axle (Newton)
- WT** Wheel Travel (Millimeter)
- α_{fw}** Slip Angle of Front Wheel (Radian)
- α_r** Rake Angle (Radian)
- α_{rw}** Slip Angle of Rear Wheel (Radian)
- α_s** Slip Angle at High Cornering Speed (Radian)
- β** Vehicle Body Slip Angle (Radian)
- δ** Steer Angle (Radian)
- δ_H** Ackermann Steering Angle at High Cornering Speed (Radian)
- δ_S** Ackermann Steering Angle in Slow Speed Cornering (Radian)

Constants, Functions, Measurements used in list of Steering System Formulas above

- constant(s):** pi, 3.14159265358979323846264338327950288
Archimedes' constant
- Functions:** **acot**, acot(Number)
The ACOT function calculates the arccotangent of a given number which is an angle given in radians from 0 (zero) to pi.
- Functions:** **asin**, asin(Number)
The inverse sine function, is a trigonometric function that takes a ratio of two sides of a right triangle and outputs the angle opposite the side with the given ratio.
- Functions:** **atan**, atan(Number)
Inverse tan is used to calculate the angle by applying the tangent ratio of the angle, which is the opposite side divided by the adjacent side of the right triangle.
- Functions:** **cos**, cos(Angle)
Cosine of an angle is the ratio of the side adjacent to the angle to the hypotenuse of the triangle.
- Functions:** **cot**, cot(Angle)
Cotangent is a trigonometric function that is defined as the ratio of the adjacent side to the opposite side in a right triangle.
- Functions:** **sin**, sin(Angle)
Sine is a trigonometric function that describes the ratio of the length of the opposite side of a right triangle to the length of the hypotenuse.
- Functions:** **tan**, tan(Angle)
The tangent of an angle is a trigonometric ratio of the length of the side opposite an angle to the length of the side adjacent to an angle in a right triangle.
- Measurement:** **Length** in Millimeter (mm)
Length Unit Conversion 
- Measurement:** **Speed** in Meter per Second (m/s)
Speed Unit Conversion 
- Measurement:** **Acceleration** in Meter per Square Second (m/s²)
Acceleration Unit Conversion 
- Measurement:** **Force** in Newton (N)
Force Unit Conversion 
- Measurement:** **Angle** in Radian (rad)
Angle Unit Conversion 
- Measurement:** **Torque** in Newton Meter (N*m)
Torque Unit Conversion 



- θ_{in} Angle of Inside Wheel Lock (Radian)
- θ_{out} Angle of Outside Wheel Lock (Radian)
- T Torque (Newton Meter)
- Ψ_c Caster Angle (Radian)



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