

Important Tire Rolling and Slipping Formulas PDF



Formulas Examples with Units

List of 17 Important Tire Rolling and Slipping Formulas

1) Gradient Resistance of Vehicle Formula ↻

Formula

$$F_g = M_v \cdot g \cdot \sin(\alpha)$$

Example with Units

$$44130.6433 \text{ N} = 9000 \text{ N} \cdot 9.8 \text{ m/s}^2 \cdot \sin(0.524 \text{ rad})$$

Evaluate Formula ↻

2) Lateral Slip Velocity Formula ↻

Formula

$$v_{\text{lateral}} = v_{\text{Roadway}} \cdot \sin(\alpha_{\text{slip}})$$

Example with Units

$$2.6067 \text{ m/s} = 30 \text{ m/s} \cdot \sin(0.0870 \text{ rad})$$

Evaluate Formula ↻

3) Longitudinal Slip Velocity Formula ↻

Formula

$$v_{\text{longitudinal}} = v_{\text{Roadway}} \cdot \cos(\alpha_{\text{slip}}) - v_B$$

Example with Units

$$4.8865 \text{ m/s} = 30 \text{ m/s} \cdot \cos(0.0870 \text{ rad}) - 25 \text{ m/s}$$

Evaluate Formula ↻

4) Longitudinal Slip Velocity for Zero Slip Angle Formula ↻

Formula

$$s_{\text{ltid}} = \Omega - \Omega_0$$

Example with Units

$$9 \text{ rad/s} = 58.5 \text{ rad/s} - 49.5 \text{ rad/s}$$

Evaluate Formula ↻

5) Roll rate or Roll stiffness Formula ↻

Formula

$$K_\Phi = \frac{\left(\frac{a}{2}\right)^2 \cdot K_t}{2}$$

Example with Units

$$72 \text{ Nm/rad} = \frac{\left(\frac{1.2 \text{ m}}{2}\right)^2 \cdot 100 \text{ N/m}}{2}$$

Evaluate Formula ↻

6) Rolling Radius of Tire Formula ↻

Formula

$$R_w = \frac{2}{3} \cdot R_g + \frac{1}{3} \cdot R_h$$

Example with Units

$$0.4167 \text{ m} = \frac{2}{3} \cdot 0.45 \text{ m} + \frac{1}{3} \cdot 0.35 \text{ m}$$

Evaluate Formula ↻



7) Rolling Resistance at Wheels Formula

Formula

$$F_R = P \cdot f_R$$

Example with Units

$$14.5\text{ N} = 1000\text{ N} \cdot 0.0145$$

Evaluate Formula 

8) Rolling Resistance Coefficient Formula

Formula

$$f_R = \frac{a_v}{r}$$

Example with Units

$$0.014 = \frac{0.007\text{ m}}{0.5\text{ m}}$$

Evaluate Formula 

9) Slip of Tire Formula

Formula

$$\lambda = \left(\frac{v - \omega \cdot r_d}{v} \right) \cdot 100$$

Example with Units

$$86.8 = \left(\frac{50\text{ m/s} - 12\text{ rad/s} \cdot 0.55\text{ m}}{50\text{ m/s}} \right) \cdot 100$$

Evaluate Formula 

10) Slip Ratio Defined According to Calspan TIRF Formula

Formula

$$SR = \Omega_w \cdot \frac{R_l}{V_{\text{Roadway}} \cdot \cos(\alpha_{\text{slip}})} - 1$$

Example with Units

$$0.1778 = 44\text{ rad/s} \cdot \frac{0.8\text{ m}}{30\text{ m/s} \cdot \cos(0.0870\text{ rad})} - 1$$

Evaluate Formula 

11) Slip Ratio Defined According to Goodyear Formula

Formula

$$SR = 1 - \frac{V_{\text{Roadway}} \cdot \cos(\alpha_{\text{slip}})}{\Omega_w \cdot R_e}$$

Example with Units

$$0.1717 = 1 - \frac{30\text{ m/s} \cdot \cos(0.0870\text{ rad})}{44\text{ rad/s} \cdot 0.82\text{ m}}$$

Evaluate Formula 

12) Slip Ratio Defined According to SAE J670 Formula

Formula

$$SR = \Omega_w \cdot \frac{R_e}{V_{\text{Roadway}} \cdot \cos(\alpha_{\text{slip}})} - 1$$

Example with Units

$$0.2072 = 44\text{ rad/s} \cdot \frac{0.82\text{ m}}{30\text{ m/s} \cdot \cos(0.0870\text{ rad})} - 1$$

Evaluate Formula 

13) Slip Ratio given Longitudinal Slip Velocity and Velocity of Free Rolling Wheel Formula

Formula

$$SR = \frac{s_{\text{lttd}}}{\Omega_0}$$

Example with Units

$$0.1818 = \frac{9\text{ rad/s}}{49.5\text{ rad/s}}$$

Evaluate Formula 



14) Slip Ratio given Velocity of Driven Wheel and Free Rolling Wheel Formula

Formula

$$SR = \frac{\Omega}{\Omega_0} - 1$$

Example with Units

$$0.1818 = \frac{58.5 \text{ rad/s}}{49.5 \text{ rad/s}} - 1$$

Evaluate Formula 

15) Traction Force Required to Climb Curb Formula

Formula

$$R = G \cdot \cos(\theta)$$

Example with Units

$$3859.4108 \text{ N} = 5000 \text{ N} \cdot \cos(0.689 \text{ rad})$$

Evaluate Formula 

16) Tractive Effort in Multi-Geared Vehicle at any given Gear Formula

Formula

$$F_t = \frac{T_p \cdot i_g \cdot i_o \cdot \eta_t}{r_d}$$

Example with Units

$$2078.0182 \text{ N} = \frac{270 \text{ N}\cdot\text{m} \cdot 2.55 \cdot 2 \cdot 0.83}{0.55 \text{ m}}$$

Evaluate Formula 

17) Wheel rate given Roll rate Formula

Formula

$$K_t = \frac{2 \cdot K_\phi}{a^2}$$

Example with Units

$$100 \text{ N/m} = \frac{2 \cdot 72 \text{ Nm/rad}}{1.2 \text{ m}^2}$$

Evaluate Formula 



Variables used in list of Tire Rolling and Slipping Formulas above

- **a** Track Width of Vehicle (Meter)
- **a_v** Distance of Opposing Torque from Vertical (Meter)
- **F_g** Gradient Resistance (Newton)
- **f_r** Rolling Resistance Coefficient
- **F_r** Rolling Resistance at Wheel (Newton)
- **F_t** Tractive Effort in Multi-gear Vehicle (Newton)
- **g** Acceleration due to Gravity (Meter per Square Second)
- **G** Weight on Single Wheel (Newton)
- **i_g** Gear Ratio of Transmission
- **i_o** Gear Ratio of Final Drive
- **K_t** Wheel Rate of Vehicle (Newton per Meter)
- **K_φ** Roll Rate/ Roll Stiffness (Newton Meter per Radian)
- **M_v** Vehicle Weight in Newtons (Newton)
- **P** Normal Load on Wheels (Newton)
- **r** Effective Wheel Radius (Meter)
- **R** Traction Force required to Climb Curb (Newton)
- **r_d** Effective Radius of Wheel (Meter)
- **R_e** Effective Rolling Radius for Free Rolling (Meter)
- **R_g** Geometrical Radius of Tire (Meter)
- **R_h** Loaded Height of Tire (Meter)
- **R_l** Height of Axle above Road Surface (Loaded Radius) (Meter)
- **R_w** Rolling Radius of Tire (Meter)
- **s_{ltd}** Longitudinal Slip Angular Velocity (Radian per Second)
- **SR** Slip Ratio
- **T_p** Torque Output of Vehicle (Newton Meter)
- **v** Forward Velocity of Vehicle (Meter per Second)
- **V_B** Circumferential Velocity of Tire under Traction (Meter per Second)

Constants, Functions, Measurements used in list of Tire Rolling and Slipping Formulas above

- **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:** **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.
- **Measurement:** **Length** in Meter (m)
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:** **Surface Tension** in Newton per Meter (N/m)
Surface Tension Unit Conversion ↻
- **Measurement:** **Angular Velocity** in Radian per Second (rad/s)
Angular Velocity Unit Conversion ↻
- **Measurement:** **Torque** in Newton Meter (N*m)
Torque Unit Conversion ↻
- **Measurement:** **Torsion Constant** in Newton Meter per Radian (Nm/rad)
Torsion Constant Unit Conversion ↻



- **V_{lateral}** Lateral Slip Velocity (Meter per Second)
- **$V_{\text{longitudinal}}$** Longitudinal Slip Velocity (Meter per Second)
- **V_{Roadway}** Axle Speed over Roadway (Meter per Second)
- **α** Angle of Inclination of Ground from Horizontal (Radian)
- **α_{slip}** Slip Angle (Radian)
- **η_t** Transmission Efficiency of Vehicle
- **θ** Angle between Traction Force and Horizontal Axis (Radian)
- **λ** Slip of Tire
- **ω** Vehicle Wheel Angular Velocity (Radian per Second)
- **Ω** Angular Velocity of Driven or Braked Wheel (Radian per Second)
- **Ω_0** Angular Velocity of Free Rolling Wheel (Radian per Second)
- **Ω_w** Wheel Angular Velocity (Radian per Second)



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