

Important Tire Behavior in Racing Car Formulas PDF



Formulas Examples with Units

List of 31 Important Tire Behavior in Racing Car Formulas

1) Angle between Traction Force and Horizontal Axis Formula ↻

Formula

$$\theta = \operatorname{asin}\left(1 - \frac{h_{\text{curb}}}{r_d}\right)$$

Example with Units

$$0.6898_{\text{rad}} = \operatorname{asin}\left(1 - \frac{0.2_{\text{m}}}{0.55_{\text{m}}}\right)$$

Evaluate Formula ↻

2) Aspect Ratio of Tire Formula ↻

Formula

$$\text{AR} = \frac{H}{W} \cdot 100$$

Example with Units

$$54.6667 = \frac{0.123_{\text{m}}}{0.225_{\text{m}}} \cdot 100$$

Evaluate Formula ↻

3) Circumference of Wheel Formula ↻

Formula

$$C = 3.1415 \cdot d_w$$

Example with Units

$$2.1362_{\text{m}} = 3.1415 \cdot 0.680_{\text{m}}$$

Evaluate Formula ↻

4) Contact Point of Wheel and Curb Distance from Wheel Center Axis Formula ↻

Formula

$$s = \sqrt{2 \cdot r_d \cdot (h - h^2)}$$

Example with Units

$$0.3639_{\text{m}} = \sqrt{2 \cdot 0.55_{\text{m}} \cdot (0.14_{\text{m}} - 0.14_{\text{m}}^2)}$$

Evaluate Formula ↻

5) Curb Force for Driven Wheel Formula ↻

Formula

$$F = \frac{G \cdot s}{r_d - h}$$

Example with Units

$$4426.8293_{\text{N}} = \frac{5000_{\text{N}} \cdot 0.363_{\text{m}}}{0.55_{\text{m}} - 0.14_{\text{m}}}$$

Evaluate Formula ↻

6) 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 ↻



7) 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 

8) 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 

9) Longitudinal Slip Velocity for Zero Slip Angle Formula

Formula

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

Example with Units

$$9.5 \text{ rad/s} = 59 \text{ rad/s} - 49.5 \text{ rad/s}$$

Evaluate Formula 

10) Mechanical Advantage of Wheel and Axle Formula

Formula

$$MA = \frac{r_d}{R_a}$$

Example with Units

$$5.641 = \frac{0.55 \text{ m}}{0.0975 \text{ m}}$$

Evaluate Formula 

11) Normal Load on Wheels due to Gradient Formula

Formula

$$F_N = M_v \cdot g \cdot \cos(\alpha)$$

Example with Units

$$76365.7405 \text{ N} = 9000 \text{ N} \cdot 9.8 \text{ m/s}^2 \cdot \cos(0.524 \text{ rad})$$

Evaluate Formula 

12) 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 

13) Tire Side Wall Height Formula

Formula

$$H = \frac{AR \cdot W}{100}$$

Example with Units

$$0.123 \text{ m} = \frac{54.66 \cdot 0.225 \text{ m}}{100}$$

Evaluate Formula 

14) 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 



15) Tractive Effort in Multi-Gear 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

$$2078.0182_N = \frac{270_{N^*m} \cdot 2.55 \cdot 2 \cdot 0.83}{0.55_m}$$

Evaluate Formula 

16) Variation of Rolling Resistance Coefficient at Varying Speed Formula

Formula

$$f_r = 0.01 \cdot \left(1 + \frac{V}{100} \right)$$

Example with Units

$$0.0145 = 0.01 \cdot \left(1 + \frac{45_{m/s}}{100} \right)$$

Evaluate Formula 

17) Wheel Diameter of Vehicle Formula

Formula

$$d_w = D + 2 \cdot H$$

Example with Units

$$0.68_m = 0.434_m + 2 \cdot 0.123_m$$

Evaluate Formula 

18) Wheel Force Formula

Formula

$$F_w = 2 \cdot T \cdot \frac{\eta_t}{D_{wheel}} \cdot \frac{N}{n_{w_rpm}}$$

Example with Units

$$6353.4398_N = 2 \cdot 140_{N^*m} \cdot \frac{0.83}{.350_m} \cdot \frac{500}{499_{rev/min}}$$

Evaluate Formula 

19) Wheel Radius of Vehicle Formula

Formula

$$r_w = \frac{d_w}{2}$$

Example with Units

$$0.34_m = \frac{0.680_m}{2}$$

Evaluate Formula 

20) Angular Velocity Formulas

20.1) Angular Velocity of Driven Wheel given Longitudinal Slip Velocity, Velocity of Free Rolling Wheel Formula

Formula

$$\Omega = s_{ltd} + \Omega_0$$

Example with Units

$$58.5_{rad/s} = 9_{rad/s} + 49.5_{rad/s}$$

Evaluate Formula 

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

Formula

$$\Omega = (SR + 1) \cdot \Omega_0$$

Example with Units

$$58.41_{rad/s} = (0.18 + 1) \cdot 49.5_{rad/s}$$

Evaluate Formula 



20.3) Angular Velocity of Free Rolling Wheel given Longitudinal Slip Velocity, Velocity of Driven Wheel Formula ↻

Formula

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

Example with Units

$$50 \text{ rad/s} = 59 \text{ rad/s} - 9 \text{ rad/s}$$

Evaluate Formula ↻

20.4) Angular Velocity of Free Rolling Wheel given Slip Ratio and Angular Velocity of Driven Wheel Formula ↻

Formula

$$\Omega_0 = \frac{\Omega}{\text{SR} + 1}$$

Example with Units

$$50 \text{ rad/s} = \frac{59 \text{ rad/s}}{0.18 + 1}$$

Evaluate Formula ↻

21) Rolling Formulas ↻

21.1) 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 ↻

21.2) 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 ↻

21.3) Rolling Resistance Coefficient Formula ↻

Formula

$$f_r = \frac{a}{r}$$

Example with Units

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

Evaluate Formula ↻

22) Slip Ratio Formulas ↻

22.1) Slip Ratio Defined According to Calspan TIRF Formula ↻

Formula

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

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 ↻

22.2) Slip Ratio Defined According to Goodyear Formula ↻

Formula

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

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 ↻



22.3) 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 

22.4) 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 

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

Formula

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

Example with Units

$$0.1919 = \frac{59 \text{ rad/s}}{49.5 \text{ rad/s}} - 1$$

Evaluate Formula 



Variables used in list of Tire Behavior in Racing Car Formulas above

- **a** Distance of Opposing Torque from Vertical (Meter)
- **AR** Aspect Ratio of Tire
- **C** Wheel Circumference (Meter)
- **D** Rim Diameter (Meter)
- **d_w** Wheel Diameter of Vehicle (Meter)
- **D_{wheel}** Diameter of Wheel (Meter)
- **F** Curb Force for Driven Wheel (Newton)
- **F_g** Gradient Resistance (Newton)
- **F_N** Normal Load on Wheels due to Gradient (Newton)
- **f_r** Rolling Resistance Coefficient
- **F_r** Rolling Resistance at Wheel (Newton)
- **F_t** Tractive Effort in Multi-gear Vehicle (Newton)
- **F_w** Wheel Force (Newton)
- **g** Acceleration due to Gravity (Meter per Square Second)
- **G** Weight on Single Wheel (Newton)
- **h** Height of Curb (Meter)
- **H** Tire Side Wall Height (Meter)
- **h_{curb}** Curb Height (Meter)
- **i_g** Gear Ratio of Transmission
- **i_o** Gear Ratio of Final Drive
- **M_v** Vehicle Weight in Newtons (Newton)
- **MA** Mechanical Advantage of Wheel and Axle
- **N** Engine Speed in rpm
- **n_{w_rpm}** Wheel Speed (Revolution per Minute)
- **P** Normal Load on Wheels (Newton)
- **r** Effective Wheel Radius (Meter)
- **R** Traction Force required to Climb Curb (Newton)
- **R_a** Radius of Axle (Meter)
- **r_d** Effective Radius of Wheel (Meter)

Constants, Functions, Measurements used in list of Tire Behavior in Racing Car Formulas above

- **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: 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.
- **Functions: sqrt**, sqrt(Number)
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **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: Angular Velocity** in Radian per Second (rad/s), Revolution per Minute (rev/min)
Angular Velocity Unit Conversion 
- **Measurement: Torque** in Newton Meter (N*m)
Torque Unit Conversion 



- **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** Wheel Radius in Meter (Meter)
- **R_w** Rolling Radius of Tire (Meter)
- **s** Contact Point Distance from Wheel Center Axis (Meter)
- **s_{ltd}** Longitudinal (Angular) Slip Velocity (Radian per Second)
- **SR** Slip Ratio
- **T** Engine Torque (Newton Meter)
- **T_p** Torque Output of Vehicle (Newton Meter)
- **v** Forward Velocity of Vehicle (Meter per Second)
- **V** Vehicle Speed (Meter per Second)
- **V_B** Circumferential Velocity of Tire under Traction (Meter per Second)
- **$v_{lateral}$** Lateral Slip Velocity (Meter per Second)
- **$v_{longitudinal}$** Longitudinal Slip Velocity (Meter per Second)
- **$V_{Roadway}$** Axle Speed over Roadway (Meter per Second)
- **W** Tire Width (Meter)
- **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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