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Tire Behavior in Racing Car Formulas

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List of 31 Tire Behavior in Racing Car Formulas

Tire Behavior in Racing Car

1) Angle between Traction Force and Horizontal Axis

Open Calculator

fx $$\theta = a\sin\left(1 - \frac{h_{curb}}{r_d}\right)$$

ex $$0.689775\text{rad} = a\sin\left(1 - \frac{0.2\text{m}}{0.55\text{m}}\right)$$

2) Aspect Ratio of Tire

Open Calculator

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

ex $$54.66667 = \frac{0.123\text{m}}{0.225\text{m}} \cdot 100$$

3) Circumference of Wheel

Open Calculator

fx $$C = 3.1415 \cdot d_w$$

ex $$2.13622\text{m} = 3.1415 \cdot 0.680\text{m}$$

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

Open Calculator

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

ex $$0.363923\text{m} = \sqrt{2 \cdot 0.55\text{m} \cdot \left(0.14\text{m} - (0.14\text{m})^2\right)}$$

5) Curb Force for Driven Wheel

Open Calculator

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

ex $$4426.829\text{N} = \frac{5000\text{N} \cdot 0.363\text{m}}{0.55\text{m} - 0.14\text{m}}$$

6) Gradient Resistance of Vehicle

Open Calculator

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

ex $$44130.64\text{N} = 9000\text{N} \cdot 9.8\text{m/s}^2 \cdot \sin(0.524\text{rad})$$

7) Lateral Slip Velocity

Open Calculator

fx $$v_{lateral} = V_{Roadway} \cdot \sin\left(\alpha_{slip}\right)$$

ex $$2.606709\text{m/s} = 30\text{m/s} \cdot \sin(0.0870\text{rad})$$

8) Longitudinal Slip Velocity

Open Calculator

$$v_{longitudinal} = V_{Roadway} \cdot \cos\left(\alpha_{slip}\right) - V_B$$

$$4.886537\text{m/s} = 30\text{m/s} \cdot \cos(0.0870\text{rad}) - 25\text{m/s}$$

9) Longitudinal Slip Velocity for Zero Slip Angle

Open Calculator

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

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

10) Mechanical Advantage of Wheel and Axle

Open Calculator

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

$$5.641026 = \frac{0.55\text{m}}{0.0975\text{m}}$$

11) Normal Load on Wheels due to Gradient

Open Calculator

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

$$76365.74\text{N} = 9000\text{N} \cdot 9.8\text{m/s}^2 \cdot \cos(0.524\text{rad})$$

12) Slip of Tire

Open Calculator

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

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

13) Tire Side Wall Height

Open Calculator

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

$$0.122985\text{m} = \frac{54.66 \cdot 0.225\text{m}}{100}$$

14) Traction Force Required to Climb Curb

Open Calculator

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

$$3859.411\text{N} = 5000\text{N} \cdot \cos(0.689\text{rad})$$

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

Open Calculator

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

$$2078.018\text{N} = \frac{270\text{N*m} \cdot 2.55 \cdot 2 \cdot 0.83}{0.55\text{m}}$$

16) Variation of Rolling Resistance Coefficient at Varying Speed

Open Calculator

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

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

17) Wheel Diameter of Vehicle

Open Calculator

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

$$0.68\text{m} = 0.434\text{m} + 2 \cdot 0.123\text{m}$$

18) Wheel Force

Open Calculator

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

$$6353.44\text{N} = 2 \cdot 140\text{N*m} \cdot \frac{0.83}{.350\text{m}} \cdot \frac{500}{499\text{rev/min}}$$

19) Wheel Radius of Vehicle

Open Calculator

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

$$0.34\text{m} = \frac{0.680\text{m}}{2}$$

Angular Velocity

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

Open Calculator

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

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

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

Open Calculator

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

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

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

Open Calculator

fx $\Omega_0 = \Omega - s_{ltd}$

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

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

Open Calculator

fx $\Omega_0 = \dfrac{\Omega}{SR + 1}$

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

Rolling

24) Rolling Radius of Tire

Open Calculator

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

ex $$0.416667\text{m} = \frac{2}{3} \cdot 0.45\text{m} + \frac{1}{3} \cdot 0.35\text{m}$$

25) Rolling Resistance at Wheels

Open Calculator

fx $$F_r = P \cdot f_r$$

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

26) Rolling Resistance Coefficient

Open Calculator

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

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

Slip Ratio

27) Slip Ratio Defined According to Calspan TIRF

Open Calculator

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

$$0.177788 = 44\text{rad/s} \cdot \frac{0.8\text{m}}{30\text{m/s} \cdot \cos(0.0870\text{rad})} - 1$$

28) Slip Ratio Defined According to Goodyear

Open Calculator

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

$$0.171659 = 1 - \frac{30\text{m/s} \cdot \cos(0.0870\text{rad})}{44\text{rad/s} \cdot 0.82\text{m}}$$

29) Slip Ratio Defined According to SAE J670

Open Calculator

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

$$0.207233 = 44\text{rad/s} \cdot \frac{0.82\text{m}}{30\text{m/s} \cdot \cos(0.0870\text{rad})} - 1$$

30) Slip Ratio given Longitudinal Slip Velocity and Velocity of Free Rolling Wheel

Open Calculator

fx $$\mathrm{SR} = \frac{\mathrm{s_{ltd}}}{\Omega_0}$$

ex $$0.181818 = \frac{9\mathrm{rad/s}}{49.5\mathrm{rad/s}}$$

31) Slip Ratio given Velocity of Driven Wheel and Free Rolling Wheel

Open Calculator

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

ex $$0.191919 = \frac{59\mathrm{rad/s}}{49.5\mathrm{rad/s}} - 1$$

Variables Used

- **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-geared 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)*
- 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)*

Constants, Functions, Measurements used

- Function: **asin**, asin(Number)
  Inverse trigonometric sine function
- Function: **cos**, cos(Angle)
  Trigonometric cosine function
- Function: **sin**, sin(Angle)
  Trigonometric sine function
- Function: **sqrt**, sqrt(Number)
  Square root function
- 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

Check other formula lists

- **Rates for Axle Suspension in Race Car Formulas**
- **Ride Rate and Ride Frequency for Race Cars Formulas**
- **Tire Behavior in Racing Car Formulas**
- **Vehicle Cornering in Race Cars Formulas**
- **Weight Transfer during Braking Formulas**
- **Wheel Centre Rates for Independent Suspension Formulas**

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