Important All Wheel Braking for Racing Car Formulas PDF

Formulas
Examples
with Units

List of 25
Important All Wheel Braking for Racing Car Formulas

1) Effects on Front Wheel Formulas

1.1) Friction Coefficient between Wheel and Road Surface with Front Wheel Brake Formula

Evaluate Formula

Formula

$$\mu = \frac{\frac{R_F \cdot b}{W \cdot \cos(\theta)} - x}{h}$$

Example with Units

$$0.49 = \frac{\frac{4625.314\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5°)} - 1.15\,\text{m}}{0.065\,\text{m}}$$

1.2) Front Wheel Reaction with All Wheel Braking Formula

Evaluate Formula

Formula

$$R_F = W \cdot (x + \mu \cdot h) \cdot \frac{\cos(\theta)}{b}$$

Example with Units

$$4625.3142\,\text{N} = 11000\,\text{N} \cdot (1.15\,\text{m} + 0.49 \cdot 0.065\,\text{m}) \cdot \frac{\cos(5°)}{2.8\,\text{m}}$$

1.3) Height of C.G. from Road Surface with Front Wheel Brake Formula

Evaluate Formula

Formula

$$h = \frac{\frac{R_F \cdot b}{W \cdot \cos(\theta)} - x}{\mu}$$

Example with Units

$$0.065\,\text{m} = \frac{\frac{4625.314\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5°)} - 1.15\,\text{m}}{0.49}$$

1.4) Horizontal Distance of C.G from Rear Axle with Front Wheel Brake Formula

Evaluate Formula

Formula

$$x = \frac{R_F \cdot b}{W \cdot \cos(\theta)} - \mu \cdot h$$

Example with Units

$$1.15\,\text{m} = \frac{4625.314\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5°)} - 0.49 \cdot 0.065\,\text{m}$$

1.5) Slope of Road from Braking with Front Wheel Reaction Formula

Evaluate Formula

Formula

$$\theta = a\cos\left(\frac{R_F}{W \cdot \frac{x + \mu \cdot h}{b}}\right)$$

Example with Units

$$5^\circ = a\cos\left(\frac{4625.314\,\text{N}}{11000\,\text{N} \cdot \frac{1.15\,\text{m} + 0.49 \cdot 0.065\,\text{m}}{2.8\,\text{m}}}\right)$$

1.6) Vehicle Weight with All Wheel Brake on Front Wheel Formula

Evaluate Formula

Formula

$$W = \frac{R_F}{(x + \mu \cdot h) \cdot \frac{\cos(\theta)}{b}}$$

Example with Units

$$10999.9995\,\text{N} = \frac{4625.314\,\text{N}}{(1.15\,\text{m} + 0.49 \cdot 0.065\,\text{m}) \cdot \frac{\cos(5^\circ)}{2.8\,\text{m}}}$$

1.7) Wheel Base with All Wheel Braking on Front Wheel Formula

Evaluate Formula

Formula

$$b = W \cdot (x + \mu \cdot h) \cdot \frac{\cos(\theta)}{R_F}$$

Example with Units

$$2.8\,\text{m} = 11000\,\text{N} \cdot (1.15\,\text{m} + 0.49 \cdot 0.065\,\text{m}) \cdot \frac{\cos(5^\circ)}{4625.314\,\text{N}}$$

2) Effects on Rear Wheel Formulas

2.1) Friction Coefficient between Wheel and Road Surface with Rear Wheel Brake Formula

Evaluate Formula

Formula

$$\mu = \frac{b - x - \frac{R_R \cdot b}{W \cdot \cos(\theta)}}{h}$$

Example with Units

$$0.49 = \frac{2.8\,\text{m} - 1.15\,\text{m} - \frac{6332.83\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5^\circ)}}{0.065\,\text{m}}$$

2.2) Height of C.G. from Road Surface with Rear Wheel Brake Formula

Evaluate Formula

Formula

$$h = \frac{b - x - \frac{R_R \cdot b}{W \cdot \cos(\theta)}}{\mu}$$

Example with Units

$$0.065\,\text{m} = \frac{2.8\,\text{m} - 1.15\,\text{m} - \frac{6332.83\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5^\circ)}}{0.49}$$

2.3) Horizontal Distance of C.G from Rear Axle with Rear Wheel Brake Formula

Evaluate Formula

Formula

$$x = b - \mu \cdot h - \frac{R_R \cdot b}{W \cdot \cos(\theta)}$$

Example with Units

$$1.15\,\text{m} = 2.8\,\text{m} - 0.49 \cdot 0.065\,\text{m} - \frac{6332.83\,\text{N} \cdot 2.8\,\text{m}}{11000\,\text{N} \cdot \cos(5^\circ)}$$

2.4) Rear Wheel Reaction with All Wheel Braking Formula

Evaluate Formula

Formula

$$R_R = W \cdot \left(b - x - \mu \cdot h \right) \cdot \frac{\cos\left(\theta \right)}{b}$$

Example with Units

$$6332.8275\,\text{N} = 11000\,\text{N} \cdot \left(2.8\,\text{m} - 1.15\,\text{m} - 0.49 \cdot 0.065\,\text{m} \right) \cdot \frac{\cos\left(5° \right)}{2.8\,\text{m}}$$

2.5) Slope of Road from Braking with Rear Wheel Reaction Formula

Evaluate Formula

Formula

$$\theta = acos\left(\frac{R_R}{W \cdot \frac{b - x - \mu \cdot h}{b}} \right)$$

Example with Units

$$4.9997° = acos\left(\frac{6332.83\,\text{N}}{11000\,\text{N} \cdot \frac{2.8\,\text{m} - 1.15\,\text{m} - 0.49 \cdot 0.065\,\text{m}}{2.8\,\text{m}}} \right)$$

2.6) Vehicle Weight with All Wheel Brake on Rear Wheel Formula

Evaluate Formula

Formula

$$W = \frac{R_R}{\left(b - x - \mu \cdot h \right) \cdot \frac{\cos\left(\theta \right)}{b}}$$

Example with Units

$$11000.0044\,\text{N} = \frac{6332.83\,\text{N}}{\left(2.8\,\text{m} - 1.15\,\text{m} - 0.49 \cdot 0.065\,\text{m} \right) \cdot \frac{\cos\left(5° \right)}{2.8\,\text{m}}}$$

2.7) Wheel Base with All Wheel Braking on Rear Wheel Formula

Evaluate Formula

Formula

$$b = \frac{W \cdot \cos\left(\theta \right) \cdot \left(x + \mu \cdot h \right)}{W \cdot \cos\left(\theta \right) - R_R}$$

Example with Units

$$2.8\,\text{m} = \frac{11000\,\text{N} \cdot \cos\left(5° \right) \cdot \left(1.15\,\text{m} + 0.49 \cdot 0.065\,\text{m} \right)}{11000\,\text{N} \cdot \cos\left(5° \right) - 6332.83\,\text{N}}$$

3) Vehicle Braking Dynamics Formulas

3.1) All Wheel Braking Retardation Formula

Evaluate Formula

Formula

$$a = [g] \cdot (\mu \cdot \cos(\theta) - \sin(\theta))$$

Example with Units

$$3.9323\,\text{m/s}^2 = 9.8066\,\text{m/s}^2 \cdot (0.49 \cdot \cos(5^\circ) - \sin(5^\circ))$$

3.2) Braking Force on Brake Drum on Level Road Formula

Evaluate Formula

Formula

$$F = \frac{W}{g} \cdot f$$

Example with Units

$$7801.0204\,\text{N} = \frac{11000\,\text{N}}{9.8\,\text{m/s}^2} \cdot 6.95\,\text{m/s}^2$$

3.3) Braking Torque of Disc Brake Formula

Evaluate Formula

Formula

$$T_s = 2 \cdot p \cdot a_p \cdot \mu_p \cdot R_m \cdot n$$

Example with Units

$$0.0547\,\text{N*m} = 2 \cdot 8\,\text{N/m}^2 \cdot 0.02\,\text{m}^2 \cdot 0.34 \cdot 0.25\,\text{m} \cdot 2.01$$

3.4) Braking Torque of Leading Shoe Formula

Evaluate Formula

Formula

$$T_l = \frac{W_l \cdot m \cdot \mu f \cdot k}{n_t + (\mu f \cdot k)}$$

Example with Units

$$1.2436\,\text{N*m} = \frac{105\,\text{N} \cdot 0.26\,\text{m} \cdot 0.35 \cdot 0.3\,\text{m}}{2.2\,\text{m} + (0.35 \cdot 0.3\,\text{m})}$$

3.5) Braking Torque of Trailing Shoe Formula

Evaluate Formula

Formula

$$T_t = \frac{W_t \cdot n_t \cdot \mu_0 \cdot k}{n_t - \mu_0 \cdot k}$$

Example with Units

$$4.4287\,\text{N*m} = \frac{80\,\text{N} \cdot 2.2\,\text{m} \cdot 0.18 \cdot 0.3\,\text{m}}{2.2\,\text{m} - 0.18 \cdot 0.3\,\text{m}}$$

3.6) Friction Coefficient between Wheel and Road Surface with Retardation Formula

Evaluate Formula

Formula

$$\mu = \frac{\frac{a}{[g]} + \sin(\theta)}{\cos(\theta)}$$

Example with Units

$$0.4898 = \frac{\frac{3.93\,\text{m/s}^2}{9.8066\,\text{m/s}^2} + \sin(5^\circ)}{\cos(5^\circ)}$$

3.7) Gradient Descend Brake Drum Force Formula

Evaluate Formula

Formula

$$F = \frac{W}{g} \cdot f + W \cdot \sin\left(\alpha_{inc}\right)$$

Example with Units

$$7802.9403\,\text{N} = \frac{11000\,\text{N}}{9.8\,\text{m/s}^2} \cdot 6.95\,\text{m/s}^2 + 11000\,\text{N} \cdot \sin\left(0.01°\right)$$

3.8) Ground Speed of Track Laying Vehicle Formula

Evaluate Formula

Formula

$$V_g = \frac{E_{rpm} \cdot C}{16660 \cdot R_g}$$

Example with Units

$$0.0263\,\text{m/s} = \frac{5100\,\text{rev/min} \cdot 8.2\,\text{m}}{16660 \cdot 10}$$

3.9) Mean Lining Pressure of Brake Lining Formula

Evaluate Formula

Formula

$$mlp = \left(\frac{180}{8 \cdot \pi}\right) \cdot \frac{F \cdot r}{\mu f \cdot r_{BD}^{\,2} \cdot w \cdot \alpha}$$

Example with Units

$$2143.1742\,\text{N/m}^2 = \left(\frac{180}{8 \cdot 3.1416}\right) \cdot \frac{7800\,\text{N} \cdot 0.1\,\text{m}}{0.35 \cdot 5.01\,\text{m}^{\,2} \cdot 0.68\,\text{m} \cdot 25°}$$

3.10) Normal Force at Brake Shoe Contact Point Formula

Evaluate Formula

Formula

$$P = \frac{F \cdot r}{8 \cdot \mu f \cdot \alpha}$$

Example with Units

$$638.4387\,\text{N} = \frac{7800\,\text{N} \cdot 0.1\,\text{m}}{8 \cdot 0.35 \cdot 25°}$$

3.11) Wheel Heat Generation Rate Formula

Evaluate Formula

Formula

$$H = \frac{F \cdot V}{4}$$

Example with Units

$$87750\,\text{J/s} = \frac{7800\,\text{N} \cdot 45\,\text{m/s}}{4}$$

Variables used in list of All Wheel Braking for Racing Car Formulas above

- **a** Retardation Produced by Braking *(Meter per Square Second)*
- a_p Area of One Piston per Caliper *(Square Meter)*
- **b** Vehicle Wheelbase *(Meter)*
- **C** Driving Sprocket Circumference *(Meter)*
- E_{rpm} Engine RPM *(Revolution per Minute)*
- **f** Vehicle Deceleration *(Meter per Square Second)*
- **F** Brake Drum Braking Force *(Newton)*
- **g** Acceleration due to Gravity *(Meter per Square Second)*
- **h** Height of Center of Gravity (C.G.) of Vehicle *(Meter)*
- **H** Heat Generated per Second at Each Wheel *(Joule per Second)*
- **k** Effective Radius of Normal Force *(Meter)*
- **m** Distance of Actuating Force from Horizontal *(Meter)*
- **mlp** Mean Lining Pressure *(Newton per Square Meter)*
- **n** Number of Caliper Units
- n_t Force of Trailing Shoe Distance from Horizontal *(Meter)*
- **p** Line Pressure *(Newton per Square Meter)*
- **P** Normal Force between Shoe and Drum *(Newton)*
- **r** Effective Wheel Radius *(Meter)*
- r_{BD} Brake Drum Radius *(Meter)*
- R_F Normal Reaction at the Front Wheel *(Newton)*
- R_g Overall Gear Reduction
- R_m Mean Radius of Caliper Unit to Disc Axis *(Meter)*
- R_R Normal Reaction at Rear Wheel *(Newton)*
- T_l Leading Shoe Braking Torque *(Newton Meter)*
- T_s Disc Brake Braking Torque *(Newton Meter)*
- T_t Trailing Shoe Braking Torque *(Newton Meter)*

Constants, Functions, Measurements used in list of All Wheel Braking for Racing Car Formulas above

- constant(s): **pi**, 3.14159265358979323846264338327950288 *Archimedes' constant*
- constant(s): **[g]**, 9.80665 *Gravitational acceleration on Earth*
- Functions: **acos**, acos(Number) *The inverse cosine function, is the inverse function of the cosine function. It is the function that takes a ratio as an input and returns the angle whose cosine is equal to that 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.*
- Measurement: **Length** in Meter (m) *Length Unit Conversion*
- Measurement: **Area** in Square Meter (m²) *Area Unit Conversion*
- Measurement: **Pressure** in Newton per Square Meter (N/m²) *Pressure 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: **Power** in Joule per Second (J/s) *Power Unit Conversion*
- Measurement: **Force** in Newton (N) *Force Unit Conversion*
- Measurement: **Angle** in Degree (°) *Angle Unit Conversion*
- Measurement: **Angular Velocity** in Revolution per Minute (rev/min) *Angular Velocity Unit Conversion*

- **V** Vehicle Speed *(Meter per Second)*
- V_g Ground Speed of Track Laying Vehicle *(Meter per Second)*
- **w** Brake Lining Width *(Meter)*
- **W** Vehicle Weight *(Newton)*
- W_l Leading Shoe Actuating Force *(Newton)*
- W_t Trailing Shoe Actuating Force *(Newton)*
- **x** Horizontal Distance of C.G. from Rear Axle *(Meter)*
- **α** Angle between Linings of Brake Shoes *(Degree)*
- α_{inc} Angle of Inclination of Plane to Horizontal *(Degree)*
- **θ** Inclination Angle of Road *(Degree)*
- **μ** Friction Coefficient Between Wheels and Ground
- μ_0 Friction Coefficient for Smooth Road
- μ_p Friction Coefficient of Pad Material
- **μf** Friction Coefficient between Drum and Shoe

- Measurement: **Torque** in Newton Meter (N*m)
  Torque Unit Conversion

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