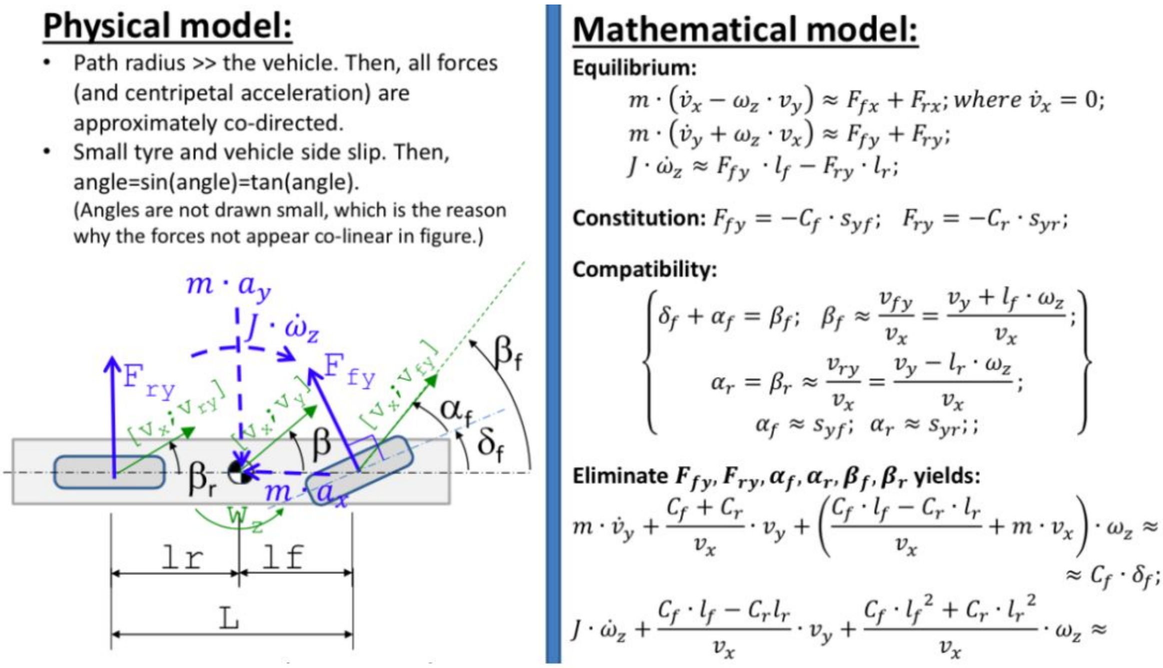
Vehicle dynamics

Bicycle model



Slip angles

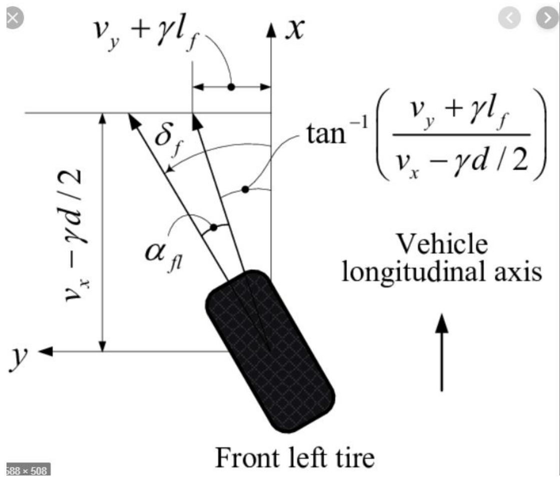
$$\alpha_{frontleft} = \delta - arctan\left(\frac{v_y + \gamma \cdot wheelbase_{front}}{v_x - \gamma \cdot track/2}\right)$$

$$\alpha_{frontright} = \delta - arctan\left(\frac{v_y + \gamma \cdot wheelbase_{front}}{v_x + \gamma \cdot track/2}\right)$$

$$\alpha_{rearleft} = arctan\left(\frac{v_y - \gamma \cdot wheelbase_{rear}}{v_x - \gamma \cdot track/2}\right)$$

$$\alpha_{rearright} = arctan\left(\frac{v_y - \gamma \cdot wheelbase_{rear}}{v_x + \gamma \cdot track/2}\right)$$

$$\gamma = yaw\ velocity$$



Aero

$$F_{downForce} = 0.5 * A_{front} * C_L * \rho * V^2$$

$$F_{drag} = 0.5 * A_{front} * C_D * \rho * V^2$$

Load transfer

Cornering

$$F_{outer} = \frac{m*g}{2} + \frac{a_y*CGH*m}{track}$$

$$F_{inner} = \frac{m*g}{2} - \frac{a_y*CGH*m}{track}$$

Braking

$$F_{front} = m * g * WD_{front} + \frac{a_x*CGH*m}{wheelbase}$$

$$F_{rear} = m * g * WD_{rear} - \frac{a_x*CGH*m}{wheelbase}$$

Accelerations

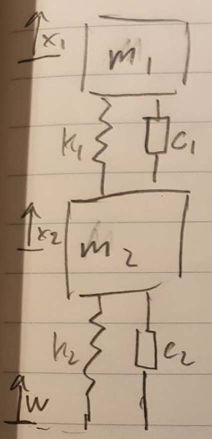
Circular motion

$$a_y = \frac{V^2}{R}$$

Unsprung Mass

Springs

Quantity	In Parallel	In Series
Equivalent spring constant is that	$k_{eq} = k_1 + k_2$	$\frac{1}{k_{eq}} = \frac{1}{k_1} + \frac{1}{k_2}$
Equivalent compliance	$\frac{1}{c_{eq}} = \frac{1}{c_1} + \frac{1}{c_2}$	$c_{eq} = c_1 + c_2$
Deflection (elongation)	$x_{eq} = x_1 = x_2$	$x_{eq} = x_1 + x_2$
Force	$F_{eq} = F_1 + F_2$	$F_{eq} = F_1 = F_2$
Stored energy	$E_{eq} = E_1 + E_2$	$E_{eq} = E_1 + E_2$



$$m_1 \ddot{x}_1 = -c_1(\dot{x}_1 - \dot{x}_2) - k_1(x_1 - x_2)$$

$$m_2 \ddot{x}_2 = c_1(\dot{x}_1 - \dot{x}_2) + k_1(x_1 - x_2) + b_2(\dot{w} - \dot{x}_2) + k_2(w - x_2)$$

Ratios

$$IR = \frac{SpringDisplacement}{WheelDisplacement}.$$

$$MR = \frac{WheelDisplacement}{SpringDisplacement}.$$

$$Wheelrate = Springrate * IR^2.$$

$$Wheelrate = Springrate / MR^2.$$