Tyre Characteristics and Vehicle Handling and Stability

\( \alpha \) – slip angle

\( M_z \) – aligning torque
Tyre Characteristics and Vehicle Handling and Stability

\( \alpha \) – slip angle

\( M_z \) – aligning torque

\( \omega_0 \) – effective wheel speed

\( \omega_w \) – actual wheel speed (\( \omega_w > \omega_0 \) in driving wheel, \( \omega_w < \omega_0 \) in braking)

\[
 r_{\text{eff}} = \frac{V_x}{\omega_0} \quad \text{– effective radius}
\]

\[
 \kappa = -\frac{V_x - r_{\text{eff}} \omega_w}{V_x} = -\frac{\omega_0 - \omega_w}{\omega_0} \quad \text{– (longitudinal) brake slip. For wheel lock} \ \omega_w = 0, \ \kappa = -1.
\]
Tyre Characteristics and Vehicle Handling and Stability

\[ F_x = F_x(\kappa, \alpha, \gamma, F_z) \]
\[ F_y = F_y(\kappa, \alpha, \gamma, F_z) \]
\[ M_z = M_z(\kappa, \alpha, \gamma, F_z) \quad \text{-- aligning torque} \]
\( \gamma \) - camber angle  \( F_{z_0} \) - rated load: when \( \gamma = 0 \) + \( \kappa = 0 \) or \( \alpha = 0 \)
Tyre Characteristics and Vehicle Handling and Stability

Forces and torque
\[ F_x = F_x(\kappa, \alpha, \gamma, F_z) \]
\[ F_y = F_y(\kappa, \alpha, \gamma, F_z) \]
\[ M_z = M_z(\kappa, \alpha, \gamma, F_z) \]

Linearised forces and torque
\[ F_x = C_{Fx} \kappa \]
\[ F_y = C_{Fa} \alpha + C_{Fy} \gamma \]
\[ M_z = -C_{Ma} \alpha + C_{Mz} \gamma \]
where \( C_s \) – stiffness
Sign Conventions for Force and Moment and Wheel Slip

(V_x > 0)

<table>
<thead>
<tr>
<th>SAE (Pacejka, this book)</th>
<th>adapted SAE</th>
<th>ISO (Besselink 2000)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>side angle</strong> (top view)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>inclination/camber angle</strong> (rear view)</td>
<td></td>
<td></td>
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<tr>
<td>side slip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \tan \alpha = \frac{V_{sy}}{V_x} )</td>
<td>( \tan \alpha = -\frac{V_{sy}}{V_x} )</td>
<td>( \tan \alpha = \frac{V_{sy}}{V_x} )</td>
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<tr>
<td>longitudinal slip</td>
<td></td>
<td></td>
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<tr>
<td>( \kappa = -\frac{V_{sx}}{V_x} )</td>
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<tr>
<td>turn slip</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>not defined</em></td>
<td>( \varphi = -\frac{\psi}{V_x} )</td>
<td><em>not defined</em></td>
</tr>
</tbody>
</table>

Modelling of Automotive Systems
Modelling of Automotive Systems

longitudinal force

side force

wheel load $F_x \neq 0$

overturning moment

rolling resistance moment

self aligning moment

$\gamma = 0$  \hspace{1cm} $\gamma > 0$

*except for Chapter 9 where $F_N = -F_z > 0$