**new coord. system** - x pointing forwards in the direction of the tyre, z is in the wheel plane pointing downwards, y defined by the two (but is in the matter of the fact wheel axis of revolution, but pointing the 'other way around')

**camber** - negative of the angle beteen wheel and car z axis when viewed from the front

**toe** - negative of the angle beteen wheel and car x axis when viewed from top

***ass*umption** - ground is parallel to xy plane

$\alpha_T := 1°$ ...toe $\qquad \alpha_C := -3°$ ...camber

**set of equations to describe the tyre coordinate system:**

$$|\vec{x}| = 1 \qquad |\vec{y}| = 1 \qquad |\vec{z}| = 1 \qquad \vec{y} = \vec{z} \times \vec{x}$$

$$x_3 := 0 \quad \text{(x parallel to the ground)} \qquad \tan(\alpha_T) = -\frac{x_2}{x_1}$$

$$\tan(\alpha_C) = \frac{z_2}{z_3} \qquad \vec{z}\cdot\vec{x} = 0 \quad \text{(to ensure z and x are perpendicular)}$$

we will calculate $x_1$ because we know it's orientation (i.e.that it is a positive value):

$$x_2 = -x_1\cdot\tan(\alpha_T) \qquad (x_1)^2 + (x_2)^2 + (x_3)^2 = (x_1)^2 + (x_1)^2\cdot\tan(\alpha_T)^2 + 0 = (x_1)^2\cdot\left(1 + \tan(\alpha_T)^2\right) = 1$$

$$x_1 := \frac{1}{\sqrt{1 + \tan(\alpha_T)^2}} \qquad x_2 := -x_1\cdot\tan(\alpha_T) \qquad x_3 := 0$$

we will calculate $z_3$ because we know it's orientation (i.e.that it is a positive value):

$$z_2 = z_3\cdot\tan(\alpha_C)$$

$$x_1\cdot z_1 + x_2\cdot z_2 + x_3\cdot z_3 = 0 \qquad z_1 = -\frac{x_2\cdot z_2 + x_3\cdot z_3}{x_1} = -\frac{x_2\cdot\tan(\alpha_C) + x_3}{x_1}\cdot z_3$$

$$(z_1)^2 + (z_2)^2 + (z_3)^2 = \left[\left(\frac{x_2\cdot\tan(\alpha_C) + x_3}{x_1}\right)^2 + \tan(\alpha_C)^2 + 1\right]\cdot(z_3)^2 = \ldots$$

$$= \frac{(x_2\cdot\tan(\alpha_C) + x_3)^2 + \left(\tan(\alpha_C)^2 + 1\right)\cdot(x_1)^2}{(x_1)^2}\cdot(z_3)^2 = 1$$

$$z_3 := \sqrt{\frac{(x_1)^2}{(x_2\cdot\tan(\alpha_C) + x_3)^2 + \left(\tan(\alpha_C)^2 + 1\right)\cdot(x_1)^2}} \qquad z_2 := z_3\cdot\tan(\alpha_C) \qquad z_1 := -\frac{x_2\cdot\tan(\alpha_C) + x_3}{x_1}\cdot z_3$$

y axis is now pretty straightforward:

$$y := \vec{z} \times \vec{x}$$

$$T := \begin{pmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{pmatrix} \qquad T = \begin{pmatrix} 0.99985 & 0.01743 & -9.13527\times 10^{-4} \\ -0.01745 & 0.99848 & -0.05234 \\ 0 & 0.05234 & 0.99863 \end{pmatrix}$$