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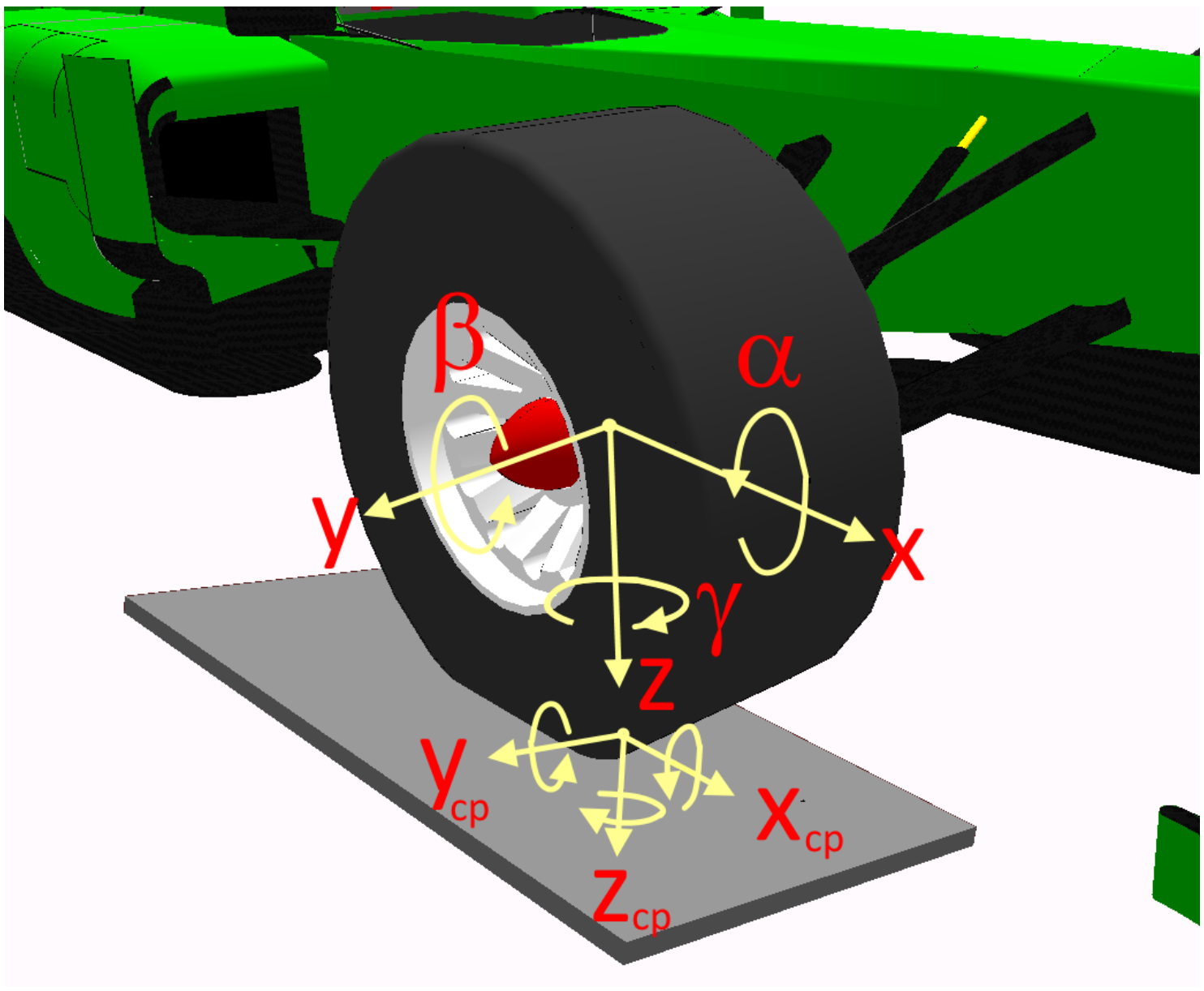
Tyres

Tyres are notoriously hard to model, at least if one wishes to get into the technicalities of the interactions of road and rubber. The Canopy Simulations tyre model aims simply to provide a set of functions which correctly mimic the large-scale behaviour of the track and the rubber, while avoiding the modelling intricacies. Furthermore, each of the Canopy Tyre model parameters has an intuitive physical interpretation; this makes the Canopy Tyre model much easier to tune and fit to driver experience and measured data than more complicated models with large numbers of abstract parameters. Bear in mind that the simulations will not drive much, if at all, beyond the peak of grip on any one tyre, so complex shaping of the post-peak behaviour of a tyre will have little or no effect in offline simulations. The table at the bottom of this page lists the entire set of tyre parameters, and proposes suitable values for each of them.

The tyre forces are computed in the *contact patch coordinate system*, a coordinate system centred at the centre of the tyre contact patch, with:

1. The z-axis normal to the track surface;
2. The y-axis mutually orthogonal to the z-axis and the hub x-axis, pointing in the positive y-direction in the design position.
3. The x-axis mutually orthogonal to the z-axis and y-axis, pointing forward in the design position.

The figure below attempts to illustrate the relationship between the hub and contact patch coordinate systems.



Vertical Stiffness

Canopy Equation:

To a first approximation the tyres behave like a linear spring in the vertical direction, however some additional features require modelling. The equation governing the loaded radius is as follows:

$$R = R_0 - \frac{|F_z|}{k_0 - k_1|a_c|} + (k_2 + k_6|F_z|)\, n^2 + k_3 p_{\text{inf}} + k_4|F_z| + k_5|F_z|^2 + k_7|F_z|p_{\text{inf}}$$

in which R_0 is the unloaded radius, F_z the vertical force on the tyre, a_c the camber angle of the tyre, n the wheel rotational speed and p_{inf} the inflation pressure. The coefficients $k_0, \ldots k_4$ are set as the user parameter vector **krLoaded**. This equation attempts to capture the effects of:

1. Vertical stiffness.
2. Reduced vertical stiffness at non-zero camber angles.
3. Growth of the tyre due to rotational speed.
4. Increase in stiffness due to increased inflation pressure.