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Overview

The car is composed of a number of subsystems:

- Aerodynamics;
- Tyres;
- Suspension;
- Powertrain;
- Brakes;
- Chassis;
- Control.

Each of the first six items in this list generates forces which are exerted on the multi-body system comprising the chassis. In response to these forces, the chassis will accelerate. The challenges, therefore in simulating the behaviour of the car are as follows:

- Compute the forces generated by each of these components; these will be a function of the current `state' of the car.
- Use these forces and information about the current car configuration to compute the accelerations of each of the car bodies.
- Use this acceleration intelligently to produce simulation information useful to Vehicle Dynamicists, Race Engineers, Aerodynamicists and Designers.

The Car State

This paragraph makes reference to the `state' of the car, which specifically means the minimal set of degrees of freedom which define the position and velocity of the car. In the default case these are:

- Position and velocity of each of the chassis degrees of freedom:
  - x-position and velocity.
  - y-position and velocity.
  - z-position and velocity.
  - roll angle and roll rate.
  - pitch angle and pitch rate.
  - yaw angle and yaw rate.
- Rocker angle and angular velocity for each of the four rockers.
- Steering rack position and velocity at the front of the car.
- Wheel rotational velocities.

Coordinate Systems

There are several coordinate systems used in the vehicle model:

- The centre chassis;
- The front and rear chassis bodies (if a flexible chassis model is being used);
- Each of the four hubs;
- Each of the four contact patches.

In the design position, on a flat track, each of these coordinate systems is defined as follows:

- **x-displacement**, +ve in the car-forward direction;
- **y-displacement**, +ve rightwards, as one looks down the car from above;
- **z-displacement**, +ve downwards;
- **roll angle**; rotation about the car x-axis, +ve rotation causes the left side of the car to rise and the right to drop;
- **pitch angle**; rotation about the car y-axis, +ve rotation causes the nose to rise;
- **yaw angle**; rotation about the car z-axis, +ve rotation moves the nose of the car rightwards.
- **slip ratio**; +ve during acceleration, produces a +ve FxTyre.
- **slip angle**; toe-out in a straight line causes +ve aSteer (on the right hand tyre), but aSlip is the angle between the direction the tyre is pointing, and the direction the tyre is going which is -ve. This produces +ve FyTyre.

Each coordinate system is *right handed*. The figure below shows the car with coordinate systems marked.