Vehicle dynamics

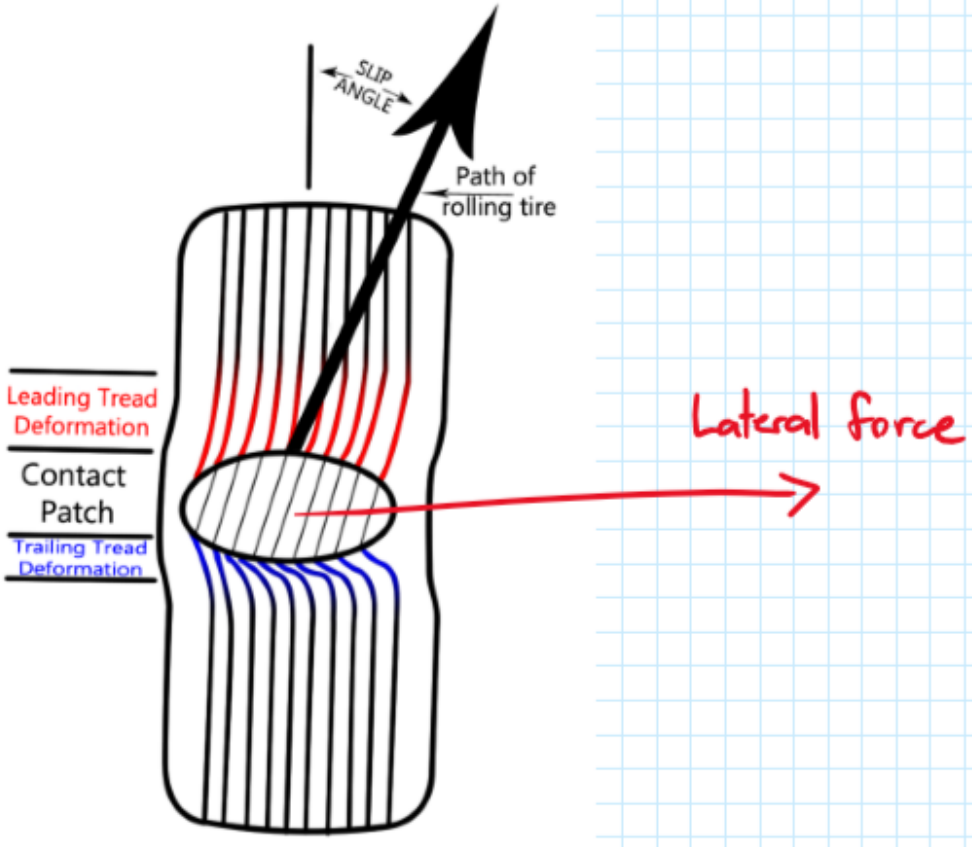
Tuesday, 18 August 2020 6:28 PM

Tyres

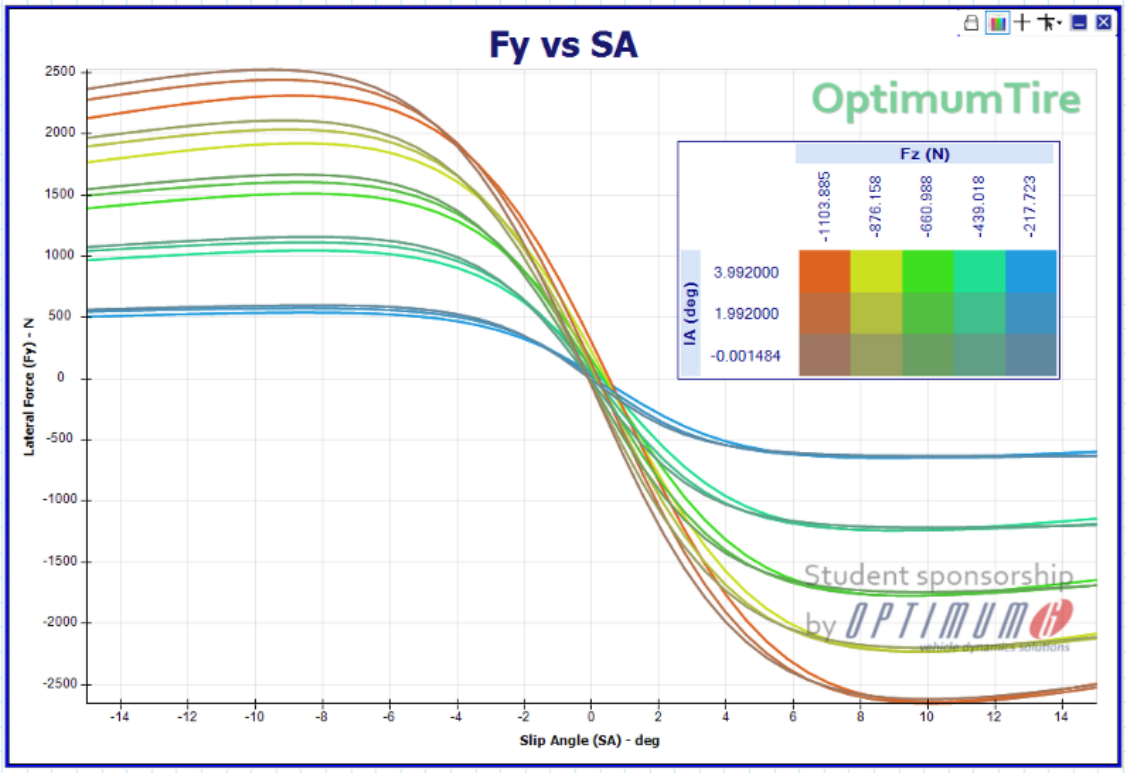
To understand how the vehicle turns, you need to understand tyres.

Tyres generate lateral force (to turn) by twisting around the contact patch (contact between road & tyre)

When you steer, the tyres are no longer pointing in the direction they are moving relative to the road. This angle difference is the slip angle.



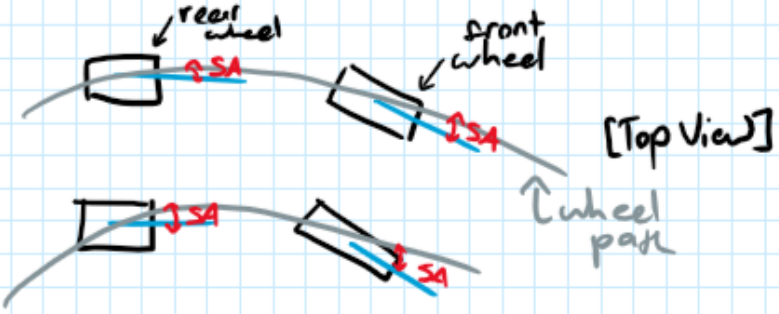
The amount of lateral force produced is proportional to slip angle. Below is an empirical relationship between lateral force and slip angle.



Steering [4 wheel model]

I will first start with a basic steering model; a four wheel car.

As the travels around this right hand corner, each of the four wheels experience a slip angle, and thus lateral force. These lateral forces accelerate the car so that it makes the turn.



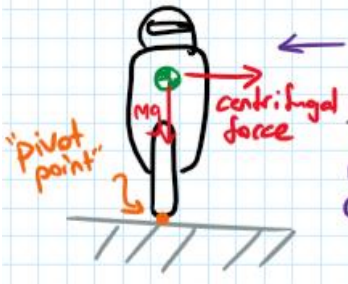
Steering [2 wheel]

Now we add complexity to the model.

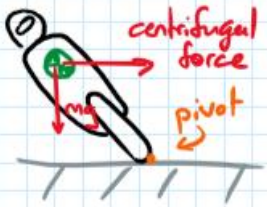
ROLL

In a four wheeled vehicle, body roll is small, usually only a couple of degrees. A motorcyle on the other hand can roll (or lean!) up to 65 degrees!

That's because a two wheeled vehicle balances its roll moments due to centrifugal (yes, it is centrifugal) force with gravatational force.



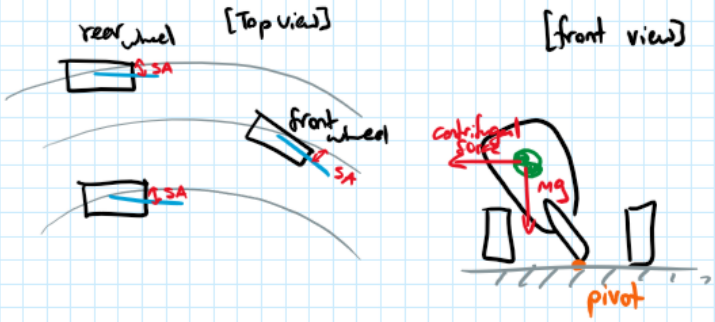
← if the rider tried to turn, he would just fall over, as there is nothing to resist the moment generated by the centrifugal force.



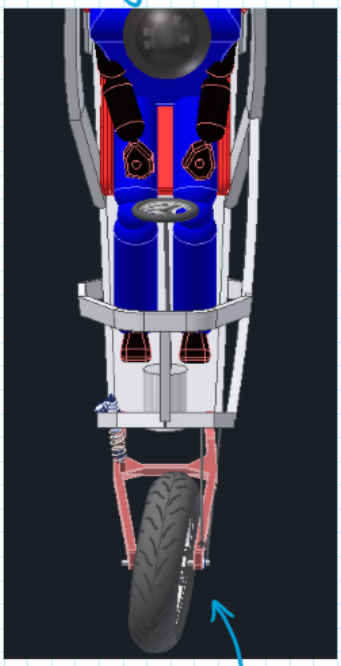
When this rider turns, the moment about the pivot is zero, as gravity opposes the centrifugal moment.

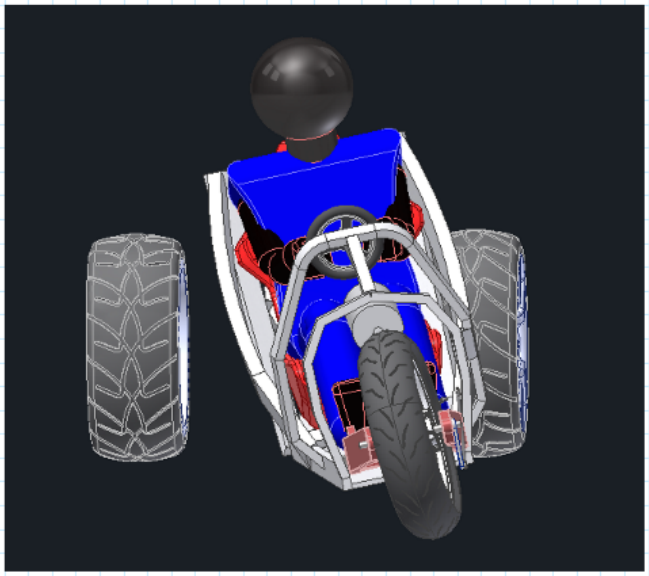
Steering [3wheel]

So to combine these ideas, the tyres generate lateral force at the contact patch, which creates the acceleration needed to turn a corner. A skinny vehicle then needs to lean over, to prevent it from toppling over due to the centrifugal force created during the turn.



So the front wheel must to create lateral force, and body must tilt to prevent toppling over.





The steering mechanism used here is an "in-hub steering mechanism" I suggest looking this up on youtube ü

Note that many simplifications have been made in this model to emphasize the fundamental idea.