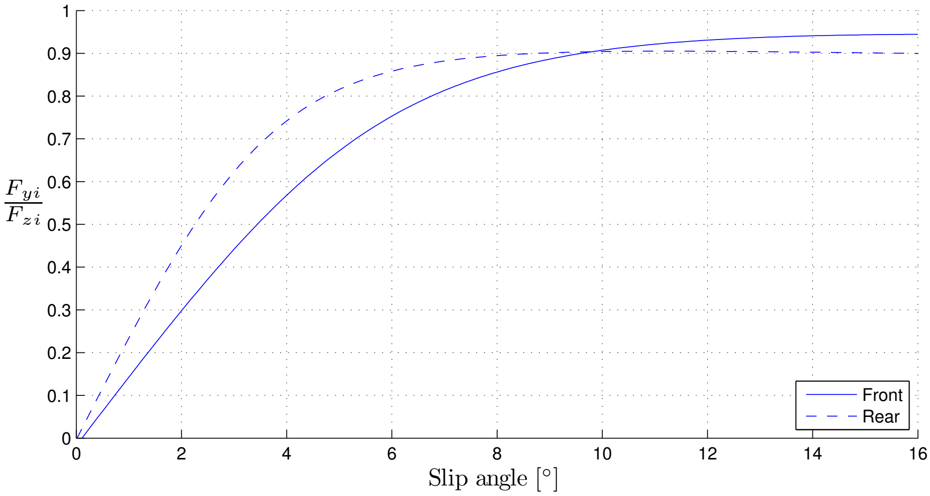
1. The normalized tire characteristics F_{yf}/F_{zf} and F_{yr}/F_{zr} are given by:



The car has a wheelbase of 2.7 m and the turning radius is 100 m (about the size of the Valla roundabout in Linkï¿½ping).

a) Determine the steer angle δ_f if the car is traveling at 70 km/h.

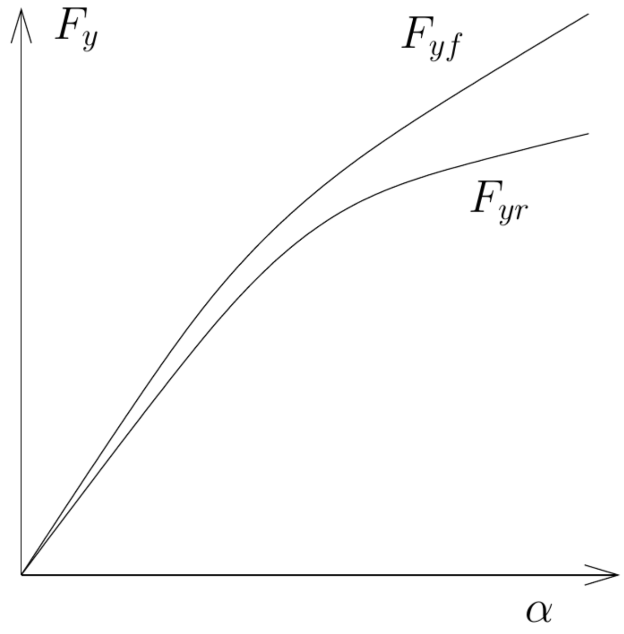
b) For which velocities is the car understeer?

c) What is the largest stationary speed that can be maintained?

2. A car is traveling in a curve with radius 80 m. For which velocities are the lateral forces below the critical values for the front and rear tires respectively? Use the brush model with constant normal pressure and assume $\mu_p = 0.8$.

3. As you can see in Figure 1.38, the resultant lateral force F_y apply behind the wheel center, not at the wheel center as we previously assumed. How is the understeer gradient affected if you consider this effect?

4. Assume that $l_2/l_1 = 1.3$ and that the lateral forces are given by the following figure:



Is the car understeer or oversteer at low lateral accelerations?
Hint: You have to use your ruler.

5. If you consider lateral load transfer, the total cornering stiffness becomes smaller than if you had considered a simple two-wheel model with twice the cornering stiffness; see Figure 1.26.

   Assume you have a neutral steered car. You can increase the lateral load transfer for either the front or the rear suspension (e.g. by changing the springs stiffness).

   a) What happens with the understeer gradient if you increase the lateral load transfer for the front suspension? (Take the effects shown in Figure 1.26 into account.)

   b) What happens with the understeer gradient if you do the same for the rear suspension instead?

6. Consider the brush model for a tire during cornering. Known data are: Length of the contact patch $l_t = 14$ cm, normal load $W = 2000$ N, stiffness $k'_y = 18 \cdot 10^5$ N/rad, and friction coefficient $\mu_p = 0.8$.

   a) What are the maximum and minimum trail that are possible to achieve using the brush model?

   b) Determine the length of the pneumatic trail if the slip angle is $\alpha = 4°$.

7. Consider a tractor and semitrailer. The tractor weighs 6000 kg and the center of gravity is located in the middle of the front and rear axle. The semitrailer weighs 16000 kg and the center of gravity is in the middle of the rear axle of the tractor and the rear axle of the semitrailer. We assume that the cornering stiffnesses are equal for all tires and that $L_t = 4$ m and $L_s = 10$ m.

   A mass m is placed above the rear axle of the semitrailer. For what values of m are there risk for ”jack-knifing” and ”trailer swing” respectively?

Answers

1. a) $\delta_f = 2.5°$

   b) For velocities less than 101 km/h with $a_y/g \approx 0.8$ (or 104 km/h if $a_y/g \approx 0.85$)

   c) 107 km/h ($a_y/g \approx 0.9$)

2. 17.7 m/s

3. The understeer gradient becomes larger.

4. The car is understeer. Since $\frac{l_2}{l_1} > \frac{C_{\alpha f}}{C_{\alpha r}} \Rightarrow 1.3 > 1.15$, measured in the figure.

5. a) The car will become understeered, $K_{us} > 0$.

   b) The car will become oversteered, $K_{us} < 0$.

6. a) 0 cm and 2.3 cm respectively.

   b) 1.9 cm

7. $m < 23000$ kg and $m > 23000$ kg respectvely.