1. Consider a passenger car in steady state cornering which is driving at 60 km/h and experiences a lateral acceleration of 4 m/s^2. The vehicle mass is 1800 kg and the cornering stiffness, for both front and rear wheels, is $5 \cdot 10^4$ N/rad. The distance from the center of gravity to the front axle is 1.1 m and 1.4 m to the rear axle.

   a) Compute the understeer coefficient and determine if the vehicle is understeered, neutral steered, or oversteered.

   b) Calculate the front and rear slip angles.

   c) What is the necessary steering angle?

2. A car weighs 1600 kg and has a wheelbase of 2.8 m. The center of gravity is 1.3 m behind the front axle and the cornering stiffnesses are $C_{\alpha f} = 4.5 \cdot 10^4$ N/rad and $C_{\alpha r} = 4.7 \cdot 10^4$ N/rad. How much load can be put in the trunk, above the rear axle, without the car becoming oversteer?

3. A neutral steer vehicle is traveling straight ahead at a longitudinal velocity of 50 km/h. The cornering stiffnesses are $C_{\alpha f} = 4.7 \cdot 10^4$ N/rad and $C_{\alpha r} = 4.5 \cdot 10^4$ N/rad. What is the resulting lateral velocity if a side force $F_y = 200$ N is applied at the vehicle's center of gravity?

4. A car has a wheelbase of 2.7 m. The center of gravity is located 1.2 m behind the front axle and 0.5 m above ground. 55% of the total braking force is placed on the front axle and 45% on the rear axle. The coefficient of road adhesion is $\mu_f = 0.7$ in the front and $\mu_r = 0.8$ rear. The coefficient of rolling resistance is $f_r = 0.015$ and we neglect air drag. Which tires will lock up first during heavy braking on flat road?

5. Consider the brush model for a tire under the action of a driving torque. Assume that the normal pressure is uniformly distributed and that there are different friction coefficients in the adhesion region and sliding region respectively. Known data are: Length of the contact patch $l_t = 14$ cm, normal load $W = 4000$ N, tangential stiffness $k_t = 15 \cdot 10^6$ N/m^2, longitudinal slip $i = 3\%$, friction coefficient in adhesion region $\mu_p = 0.8$, and friction coefficient in sliding region $\mu_s = 0.65$.

   a) Determine how the tractive force per unit contact length $\mathrm{d}F_x/\mathrm{d}x$ varies in the contact patch.

   b) Determine the tractive force F_x.

Answers

1. (a) $K_{us} = 0.0212$. The vehicle is understeered.
   (b) $\alpha_f = 2.31°, \quad \alpha_r = 1.82°$
   (c) $\delta = 2.56°$
2. 152 kg.
3. 1.5 cm/s.
4. The rear wheels lock up first.
5. (a)
$$\frac{dF_x}{dx} = \begin{cases} k_t i x, & \text{för } 0 \leq x < l_c \\ \mu_s W / l_t, & \text{för } l_c < x \leq l_t \end{cases}$$
   where $l_c = 5.1$ cm.
   (b) 2.24 kN.