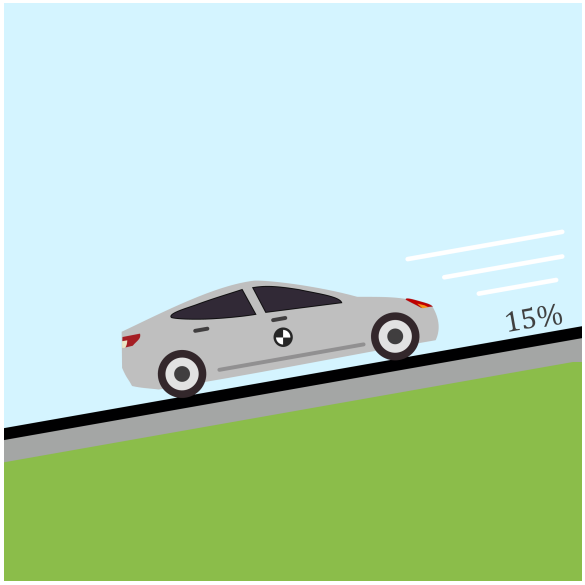
Car Parking Brake



If you park on a hill with a slope of 15% with the car held by the parking brake, will the car, weighing 1250 kg, stay in place if the frictional force is $F_p = 2000$ N? Take $g = 10$ m/s^2. Moreover, there is a wind force with a magnitude equal to 10% of the frictional force pushing against the front of the car. Will the car stay in place?

Using known expressions:

$$\sum F_x = m \cdot a_x \tag{1}$$

Given:
Mass of the car: $m = 1250$ kg
Gravitational acceleration: $g = 10$ m/s^2
Frictional force: $F_p = 2000$ N
Wind force: $F_{wind} = 10\% \cdot F_p = 200$ N
Slope: 15% $\Rightarrow$ $\theta = \arctan\left(\frac{15}{100}\right) = 8.53°$

Figure 1 shows a FBD of this problem. From this figure it can be seen that F_g in the x-direction is equal to $F_{g,x} = \sin\theta \cdot F_g$. Inserting this in Equation 1 results in.

$$\sum F_x = m \cdot a_x = F_p - F_{wind} - F_{g,x} = 0 \quad \Rightarrow \quad F_p = F_{wind} + \sin\theta \cdot F_g \tag{2}$$

For the car to stay in place the frictional force should be greater than the wind force plus the gravitational force in the x-direction.

$$F_p > F_{wind} + \sin\theta \cdot F_g \quad \Rightarrow \quad 2000 > 200 + \sin 8.53 \cdot m \cdot g \tag{3}$$

$$2000 > 200 + \sin 8.53 \cdot 1250 \cdot 10 \quad \Rightarrow \quad 2000 > 200 + 1854 \quad \Rightarrow \quad 2000 > 2054$$

Since this is not true, it means that the frictional force is too low to keep the car in place. Thus the car starts moving down.

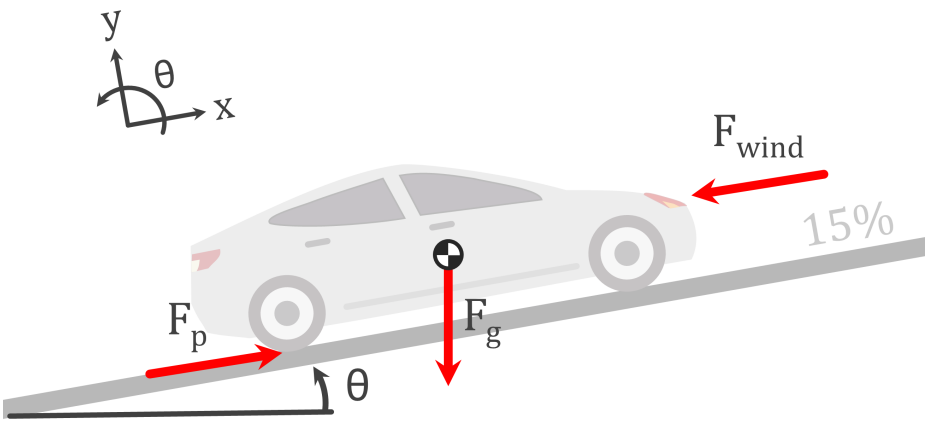


Figure 1: FBD of a car on a slope