4th International Team Mathematical Modelling Tournament
for high-school students (MMT-2021)

MMC/Mammoth-2021 Problem

Is “parking zone” efficient?

There are two types of organized parallel car parking areas at the roadside: marked parking lots, which are divided into individual parking spaces (fig.1) and undivided parking lots (“parking zones”), which either have no marking at all or may have a common marking line separating them from the road (fig.2). Under the Traffic Code, if there are markings for individual parking spaces, drivers must respect them and park only one car in one parking space. In the second case, drivers choose parking spaces within the permitted area freely.

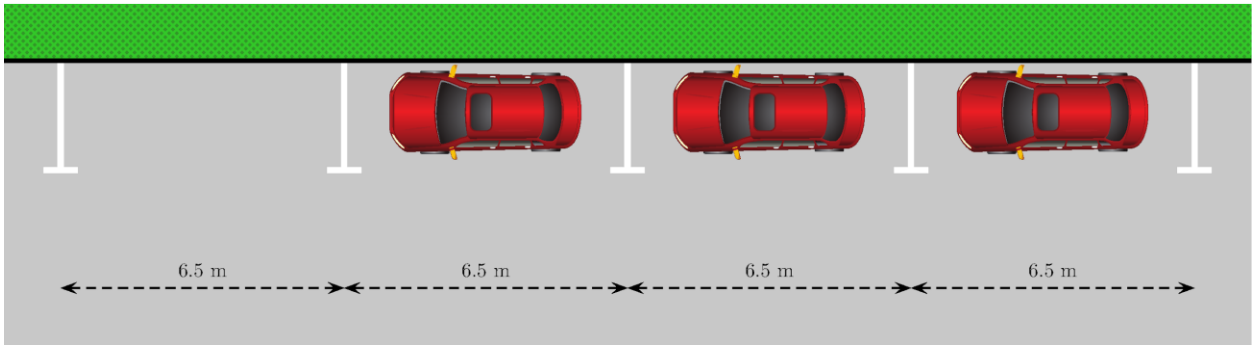

Figure 1. Parallel parking lot with marking of individual spaces.

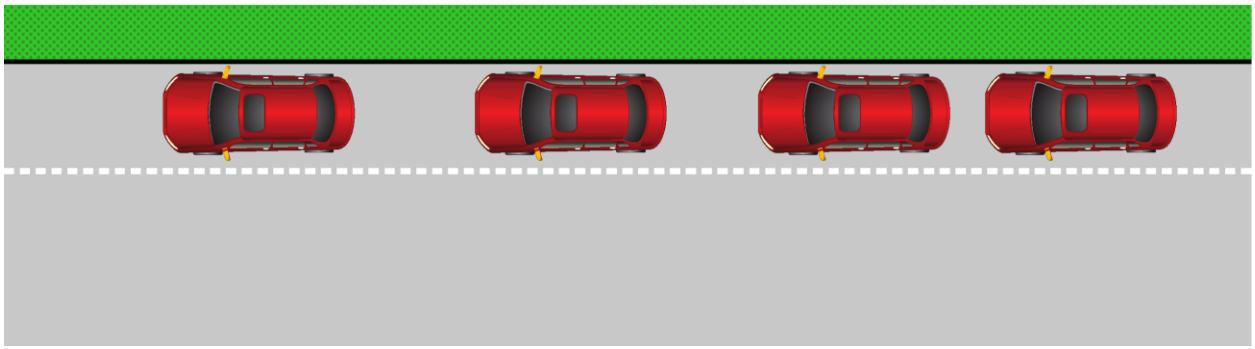

Figure 2. Parallel parking lot without marking of individual spaces, or “parking zone”.

In the case of the standard marking of the first type, the length of each parking space is 6.5 meters, which significantly exceeds the average length of a car and leads to a “sparser” parking than it is possible.

At first glance, the “parking zone” could solve this problem because drivers can park as tightly as possible, accommodating more cars on the same street length. However, since cars and other vehicles are noticeably different in length and the drivers choose parking spaces in the free zone arbitrarily, the gaps formed between the cars can be quite big, but still insufficient for parking new arriving cars in them.

Which type of parking is better for a large city in terms of maximizing the average number of parked cars over a given length of a parking lot?

Tasks:

1) Determine the distribution of vehicle lengths in your city (i.e., how often vehicles of each possible length are found). It is recommended to present the results as a histogram or a graph.
2) Determine the distribution of the gaps between parked cars that the drivers leave in order to be able to drive out of the parking lot (provided there is no division into parking spaces).
3) Suppose that the marking of a parking lot into individual spaces has been erased and now cars park on it in the optimal way (taking into account the distributions from tasks 1 and 2). By how much, on average, will the capacity of this parking lot grow?
4) Build a mathematical model that describes the process of parking in a “parking zone” (taking into account arriving and leaving cars and the variability of drivers' behavior when they choose a place to park) and estimate the average number of cars per “parking zone” of a certain length.
5) Compare the efficiency of parking lots of the first and second types in a real application in the city. Which type is more efficient and how much more?
6) How will the comparison results change if you change the assumptions about the standards of driver behavior used in your mathematical model or if the length of the marked parking space is changed from 6.5 m to 7.5 m or 5.5 m?

Remark: Assume that all drivers strictly observe the Traffic Code, strictly obey the markings in the parking lot of the first type, and do not “lock up” other parked vehicles in the parking lot of the second type (that is, leave enough space for them to drive out).