Name:	First name:	Matrikel number:

Exam to the Lecture
Traffic Dynamics and Simulation
SS 2023

Total 120 points

Problem 1 (40 points)

(a) What is the difference between microscopic and macroscopic traffic flow models? Give the main dynamical variables of each model class.

(b) Determine if, in following situations, microscopic or macroscopic models are suited better. Justify your decisions in a few words.

- (i) Determine if it is likely that construction work at a freeway will lead to traffic jams in the vacation season
- (ii) will more assisted or autonomous vehicles lead to more or less congestions?
- (iii) creating responsive surrounding traffic in driving simulators
- (iv) influence of dyamic routing on congestions and traffic flow quality
- (v) will traffic jams lead to more or less foel consumption? Does it depend on the kind of jam (homogeneous or traffic waves)? the surrounding traffic flow.

(c) Give an example of a model formulated mathematically as a

- set of coupled ordinary differential equations
- iterated map
- partial differential equation
- cellular automaton

Just giving a model name is enough

(d) In microscopic traffic flow models, it is possible to model different driving styles. What would you to do model

- fast vs slow drivers
- agile/responsive vs sluggish/unresponsive drivers
- aggressive vs relaxed drivers
- anticipative/experienced vs not experienced drivers?

You could use a specific model such as the Intelligent Driver Model or just argue in general terms

Name:	First name:	Matrikel number:

Problem 2 (20 points)

Consider a parking lot of a shopping center on Saturday (opening hours 9:00-14:00) which is empty before 09:00h. The customers spend between 0 and 2 hours, uniformly distributed, at the shop location. The number of arriving vehcles in one-hour intervals is given as follows:

Time interval	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00
Arrival	500	1 000	1 000	800

Give the occupancy numbers on this parking place at the times 09:00, 10:00, 11:00, 12:00, and 13:00.

Problem 3 (20 points)

(a) Given is a Diesel ICV (internal combustion vehicle) whose engine has a specific consumption of 300 ml/kWh (assumed to be constant) and following car properties:

- mass $m = 1\,400\,\text{kg}$,
- cd-value $c_d = 0.32$,
- front area $A = 2\,\text{m}^2$,
- rolling friction coefficient $\mu = 0.015$,
- auxillary power demand $P_0 = 2\,\text{kW}$.

Furthermore, we have $g = 9.81\,\text{m/s}^2$ and the air density $\rho = 1.3\,\text{kg/m}^3$.

Give the driving resistance F and the fuel consumption per 100 km when driving at a constant speed of (i) 50 km/h, (ii) 130 km/h

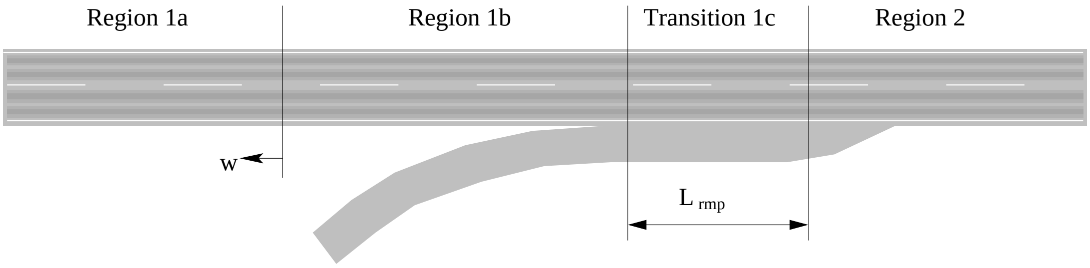
(b) a comparable BEV (battery-electric vehicle) has the same vehicle attributes as the Diesel car apart from its mass ($m = 1\,800\,\text{kg}$) and auxillary power demand $P_0 = 1\,\text{kW}$. Furthermore, the electrical motor has a constant efficiency of 0.9. Furthermore, the battery has a constant efficiency of 0.9 at charging and discharging. Give the driving resistance F and the electrical energy needed from the battery per 100 km when driving at a constant speed of (i) 50 km/h, (ii) 130 km/h.

hint: both the motor and discharging efficiency are in the denominator of the formula for the needed electrical energy

Name:	First name:	Matrikel number:

Problem 4 (40 points)

Given is a two-lane freeway section with an onramp:

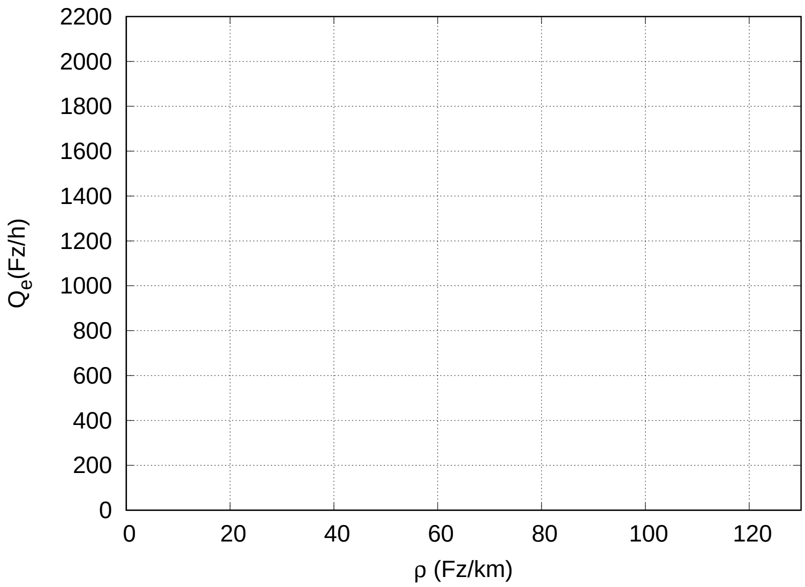


The onramp vehicles always force their way into the main road, so there is no congestion at the ramp. Traffic flow is described by a LWR model with the fundamental diagram

$$Q_e(\rho) = \min\left[V_0\rho, \frac{1}{T}\left(1 - l_{\text{eff}}\rho\right)\right].$$

with $l_{\text{eff}} = 8\,\text{m}$, $T = 1.4\,\text{s}$, and $v_0 = 108\,\text{km/h}$.

(a) Plot the fundamental relation for the lane-averaged quantities into following diagram:



(b) On the main road, there is a constant total demand of 3 000 veh/h, and on the onramp 500 veh/h. Give for each of the regions 1 and 2

- The total flow Q_{tot} and the flow per lane Q
- The total density ρ_{tot} and the density per lane V

Argue that no traffic breakdown is created for this situation which also means there no need to distinguish between the Regions 1a and 1b

(c) Why it is sensible [vernünftig] to define Q_{tot} and ρ_{tot} but not V_{tot}?

(d) At 16:00 h, a detector 9 000 m upstream of the onramp (beginning of Region 2) measures a sudden increase of the demand from $Q_{\text{in}} = 3\,000$ veh/h to 4 000 veh/h. Argue that this will lead to a traffic breakdown once this surge in the demand reaches the onramp. Determine the time when this happens

(e) Assuming that the drivers of the ramp vehicles always force their way to the main road determine the total and per-lane flow, total and per-lane density, and speed in the regions 1a, 1b, and 2

(f) Determine the velocity of the upstream front of the developing region 1a of congestion (if you did not solve (e), use $Q_{1b} = 3\,820$ veh/h, $\rho_{1b} = 35$ veh/km and ρ_{1a} and Q_{1a} from the condition that Region 1a is uncongested and determined by the inflow.