

RESIT - M8 TRAFFIC FLOW DYNAMICS

201400147

June 10, 2020
8:45-10:45

Dear student,

On each page of your handwritten exam, you should clearly mention your full name, student number and educational program. Furthermore, you must write down this integrity statement:

"I will make this test to the best of my own ability, without seeking or accepting the help of any source not explicitly allowed by the conditions of the test."

and then sign it.

The exam consists of 4 problems. Maximum scores are listed in the table below. However, the time you have for this exam is unlikely to be enough to finish all problems. As a result, the end score is the total score divided by 7, and not 9. However your endscore will never exceed 10, even in the case you finish all problems with the right answer.

Good luck

Eric van Berkum

problem	max score
1	10
2	20
3	30
4	30
total	90

1. [10 points] In the peak hour the intensity of left turning vehicles at an intersection equals 360 veh/h and the period they are confronted with red light is 60 s. Suppose the goal is to guarantee that in 96 % of the cycles the length of the lane is sufficient. What is the minimum length in meters of a lane for left turning vehicles. Assume that the arrival process is Poisson distributed and assume further that jam density is 160 veh/km.

(you may use any online Poisson Distribution Calculator such as <https://stattrek.com/online-calculator/poisson.aspx>)

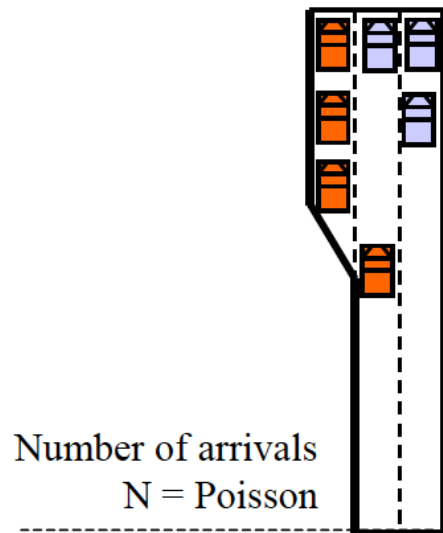


Figure 1: Example of a left lane with capacity for 3 vehicles

2. [20 points] A study of freeway flow at a particular site has resulted in a calibrated speed-density relationship, as follows:

$$u = 57.5(1 - 0.008k)$$

From this relationship:

- (a) [5 points] Find the free-flow speed and jam density
- (b) [10 points] Derive the equations describing flow versus speed and flow versus density.
- (c) [5 points] Determine the capacity of the site mathematically

3. [30 points] Consider a road at a signalized intersection. The traffic can be described with a triangular fundamental diagram with a capacity of 1500 veh/h, a free flow speed of 50 km/h and a wave speed (between capacity and jam density state) of -15 km/h. The inflow is 1000 veh/h. At $t = 0$, the traffic light turns red for 2 minutes. Then, the traffic light turns green for 0,5 minute, after which the traffic light turns red again for 1 minute. Afterwards, the traffic light stays green. Determine the different states of the traffic flow, sketch the fundamental diagram in the flow-density plane, and position the states in the diagram. Further sketch the shockwaves and states in the (t, x) -plane. Determine the speed of the shockwaves using shockwave theory,.

4. [30 points] Helly's car-following model is given by the following equations:

$$a = \alpha \Delta v + \beta(s - s^*) \quad (1)$$

$$s^* = x_0 + vT \quad (2)$$

In this equation a is the acceleration, v denotes the speed, Δv the difference in speed between the leader and its predecessor, and s the spacing. Parameters in the model are α , β , x_0 and T . The interpretation of the parameters, and the meaning of s^* is left to yourself. For reasons of simplicity, the time dependence and reaction time are ignored in this question.

- (a) [10 points] Derive the equation of the fundamental diagram, $q = q(k)$, from the above equation for the congested branch. So in the congested branch the above equations hold. Hint: use the relation $v = v(s)$ in the derivation
- (b) [10 points] The following parameters are found to fit the traffic best: $\alpha = 0,3 \text{ s}^{-1}$, $\beta = 0,08 \text{ s}^{-2}$, $x_0 = 20 \text{ m}$, $T = 1 \text{ s}$ (here s means second and m meter). Besides the car-following part, also a free speed is required to derive a full fundamental diagram. This is found to be 30 m/s . Compute the capacity of the road in veh/h . (in case you were not able to find an answer at (a), you can describe how you would proceed, given the fact that the relationship to be found in (a) indicate that both q and v decrease with k in the congested branch, so the higher the density, the lower the speed and the lower the flow)
- (c) [10 points] The Dutch government recommends drivers in fog: "Half the speed, double the space headway to the predecessor". Suppose everyone takes this advice. Compute the capacity of the road in the fog. You may (but do not need to) relate this to question (b); in case you did not find an answer to that question, assume an answer and state so explicitly.