Exam 4821

Duration – 3 hours. Points are indicated for each question.
The exam has 5 questions
54 points can be obtained. However, note that half of the points is not necesserily suffcient for a 6.
Use your time wisely!

Remarks:
– Allowed: calculator (but no smartphones...)
– Not allowed: working with pencil (use a pen instead)
– Put labels at all your graph axes
– For some questions, a indcative number of words is given as guidance for the required level of detail. Your answer may be shorter or longer. It will be judged on the good elements in there, but for all wrong answers points will be deducted.
– **Make sure you provide the calculus procedure as well as the result in order to get the maximum points.**

1) Short questions (12 points)

A road has a capacity of 2000 veh/h, a free flow speed of 120 km/h, a critical density of 25 veh/km and a jam density of 150 veh/km.

a) Draw a realistic fundamental diagram in the with the above properties, both in the flow-density plane and in the speed-density plane; indicate how speed can be found in the flow-density diagram. (4 pt)

b) Describe briefly (100 words) the assumptions in Daganzo's theory of slugs and rabbits (3 pt)

c) What are cumulative curves, and how are they constructed? (1 pt)

d) What is a vertical queing model and how is this related to cumulative curves (2 pt)

e) What is higher, the space mean speed of the time mean speed? Why? (1 pt)

f) How can the space mean speed be calculated from individual local speed observations v_i. Give an equation. (1pt)

2) State recognition (10 points)

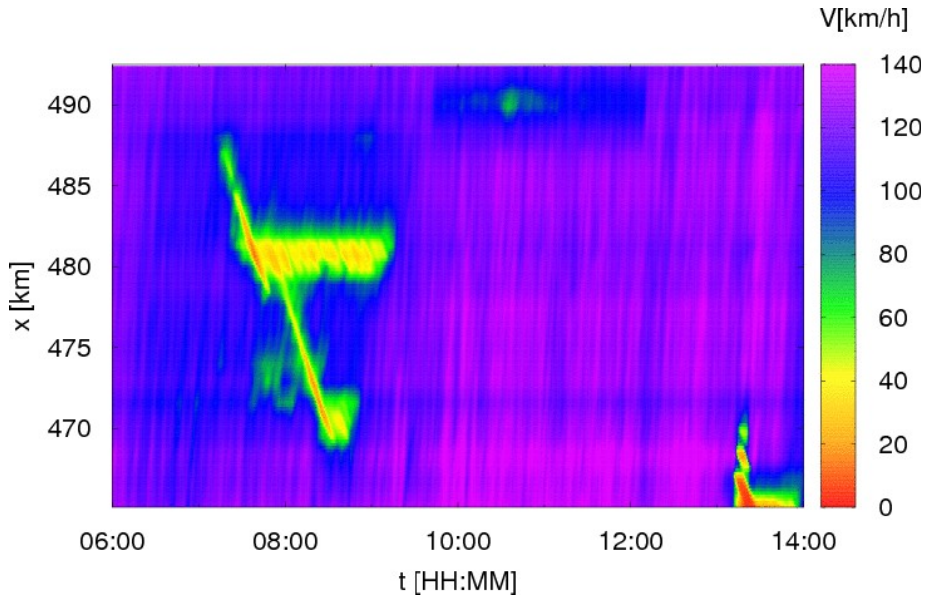
a) What are the phases according to three-phase traffic flow theory? How are they characterised? (2 pt)

Below, you find some traffic state figures from www.traffic-states.com. For each figure, indicate:

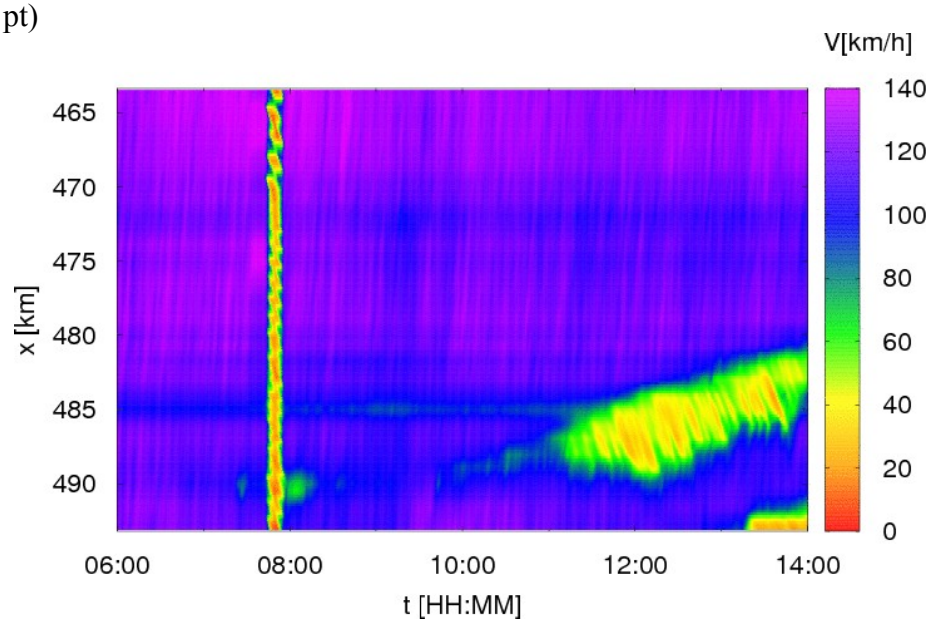
I) The driving direction (top-down or bottom-up, and explain why based on traffic flow theory (0.5pt per figure, spread over b-d) and

II) the traffic characteristics present, and the most likely causes for these (6.5 pt, spread over b-d)

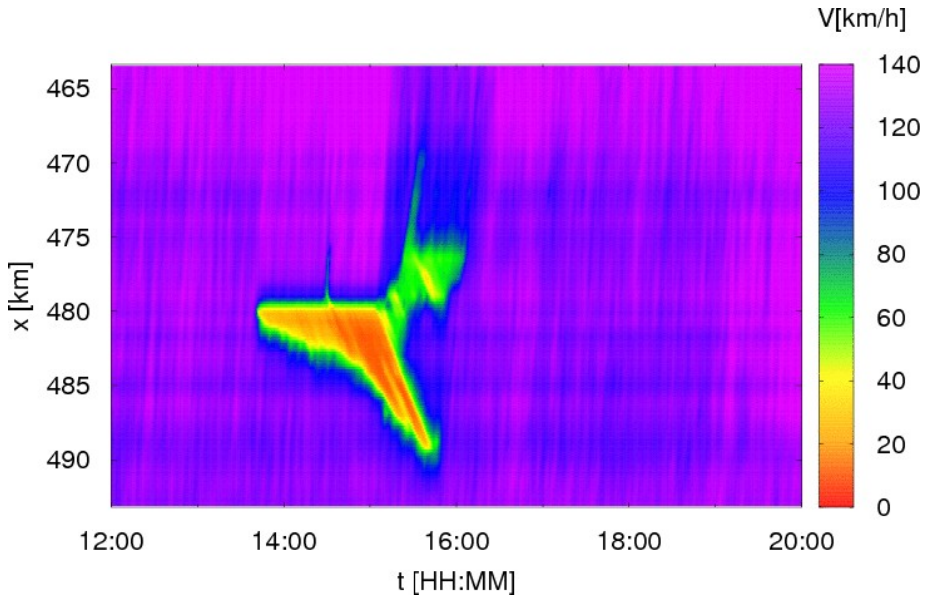
b. (up to 10.00 am) (2 pt)



c (2.5 pt)



d (3.5 pt)



3) Simulation model (11 points)

a) Explain briefly (indication: 100 words and 1 graph) Newells car-following model (3 pt)
b) Name the three types of (in)stability in traffic flow, and explain briefly their effect (50 words and 1 graph per type) (3 pt)
c) Can multi-anticipation improve stability? Which type and how? (3 pt)
d) How can lane-changing cause a breakdown? (indication: 50 words) (1 pt)
e) How can lane-changing prevent a breakdown? (Hint: use the lane distribution.) (2 pt)

4) Moving bottleneck (12 points)

Imagine a truck drivers strike in France on a 3-lane motorway from time t=t0. For the road you may assume a triangular fundamental diagram with a capacity of 2000 veh/h/lane, a critical density of 25 veh/km/lane and a jam density of 125 veh/h/lane. Suppose there is no traffic jam at t<t0, and a constant demand of 5000 veh/h. Assume the truck drivers drive at 30 km/h, not allowing any vehicle to pass.

a) What is the maximum flow on the road behind the trucks? (3 pt)
b) Sketch the traffic flow operations in a space-time diagram. Pay attention to the direction of the shockwave (upstream/downstream), and note the propagation speeds of the other waves. (3 pt)

After a while, the trucks leave the road.

c) Sketch again the traffic operations in the space time diagram. Do this until the traffic jam is solved (if applicable), or until the traffic states propagate linearly if demand does not change. (3 pt)
d) What is the speed at which the tail of the queue propagate backwards? (1 pt)
e) In the plot of question c), draw the trajectory of the vehicle arriving at the tail of the queue at the moment the strike ends (Use a different colour or style than the shockwaves). What is the speed of the vehicle in the jam? (2 pt)

5) Marathon Delft (9 points)

Imagine a marathon organised in Delft. There are 30.000 participants, starting at a roadway section which is 25 meters wide.

a) Give a realistic estimate for the capacity of the roadway in runners per hour. Base your answer on the width and headway of a runner (3 pt)
b) How long would it take for all runners to start? (1 pt)

Suppose the runners have uniform distribution of running times from 2.5 to 4.5 hours, and all run at a constant speed.

c) Given your answer on question 5a, what width of the road is needed halfway the track? For reasons of simplicity, you may assume that they all start at the same moment (instead of your answer at question 5b). (5 pt)