

Faculty of Engineering Technology

Written Exam	Public Transport in Urban Areas
Teacher	Van Zuilekom, Van Es, Bakker and Hartmann
Course code	201600131
Date and time	22-01-2018, 13:45-16:45
Location	Term
Remarks	Closed book, calculator allowed Formulas and tables are, when necessary, are part of the question. Print in color

Calculation of the marks for the written exam, C :

$$C = 1 + 9 \cdot \frac{P}{P_{max}}$$

Where P is the sum of points and the maximum number of points is P_{max} .

Available time is 180 minutes. The points per question roughly reflect the time needed for answering the question.

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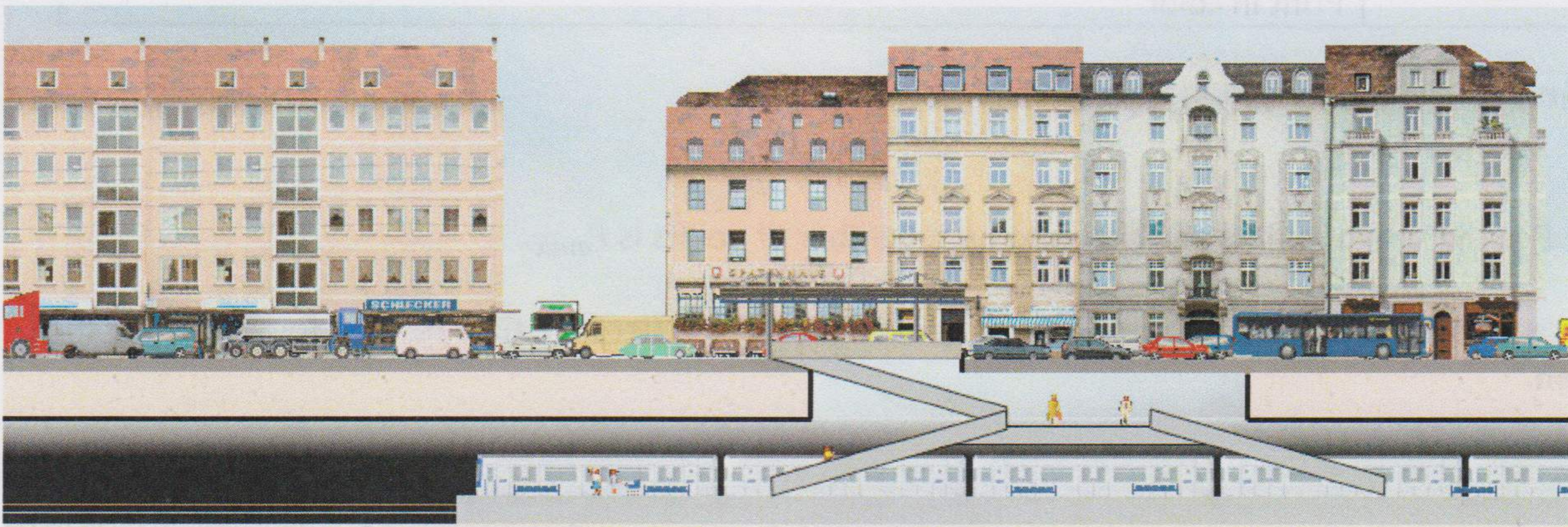
Question 1 [3 points] High speed trains

High speed trains sometimes are referred to as 'airplanes without wings'. True, since they operate in the same transport market as continental air traffic.

Name three examples of on board facilities / level of service which are specific for the product – market combination high speed trains

Question 2 [6 points] Track concepts

There are three main principles to fit a rail line in an urbanized area. Street level, Minus 1 and Plus 1. The two most common used ones are Street level and Minus 1. See illustrations below.



Minus 1 ↑



Level ↑

- [3 points] Name for each of the two principles 'Street level' and 'Minus 1' a suitable track concept.
- [3 points] Describe for each chosen track concept two specific characteristics and mention if this characteristic is positive or negative.

Question 3 [4 points] ERTMS

ERTMS level 1 is often referred to as 'just another train protection system'. This statement is true. Only ERTMS levels 2 and 3 offer new facilities. Describe in your own words the working (/main characteristics) of ERTMS levels 1, 2 and 3.

Question 4 [8 points] Radius, speed and cant

The relationship between speed, radius, acceleration, cant and gauge are given by:

$$\frac{v^2}{R} = a + \frac{(g \cdot h)}{s}$$

Where:

v = speed [m/s]

R = radius [m]

a = acceleration [m/s²]

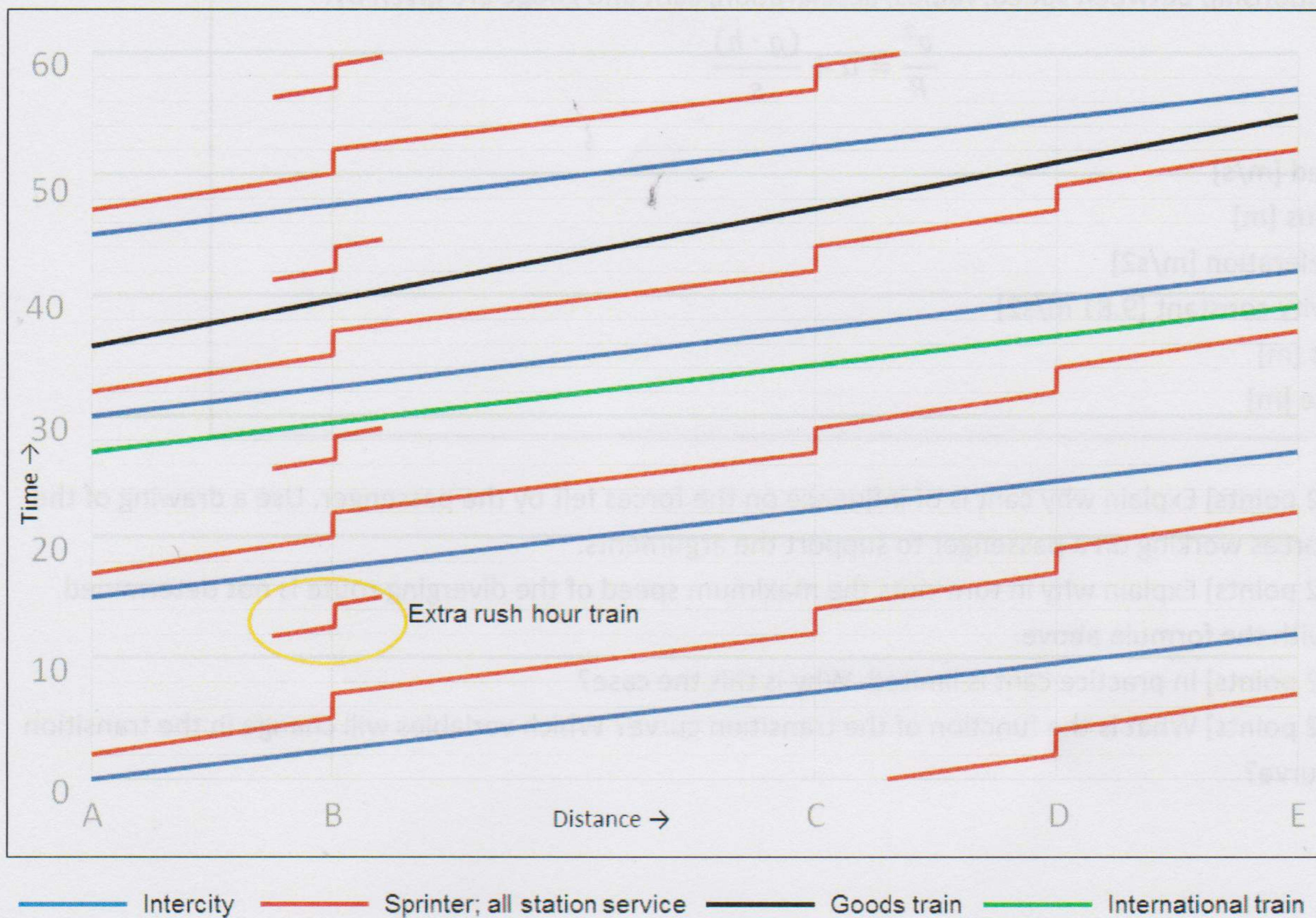
g = gravity constant [9.81 m/s²]

h = cant [m]

s = gauge [m]

- [2 points] Explain why cant is of influence on the forces felt by the passenger. Use a drawing of the forces working on a passenger to support the arguments.
- [2 points] Explain why in turn-outs the maximum speed of the diverging route is not determined with the formula above.
- [2 points] In practice cant is limited. Why is this the case?
- [2 points] What is the function of the transition curve? Which variables will change in the transition curve?

Question 5 [6 points] Extra peak hour trains



See the above timetable. The city council of town B posts a request to both the passenger transport company and the rail infrastructure network manager for extra trains during peak hours (and vice versa). Every 7,5 minutes instead of every quarter of an hour.

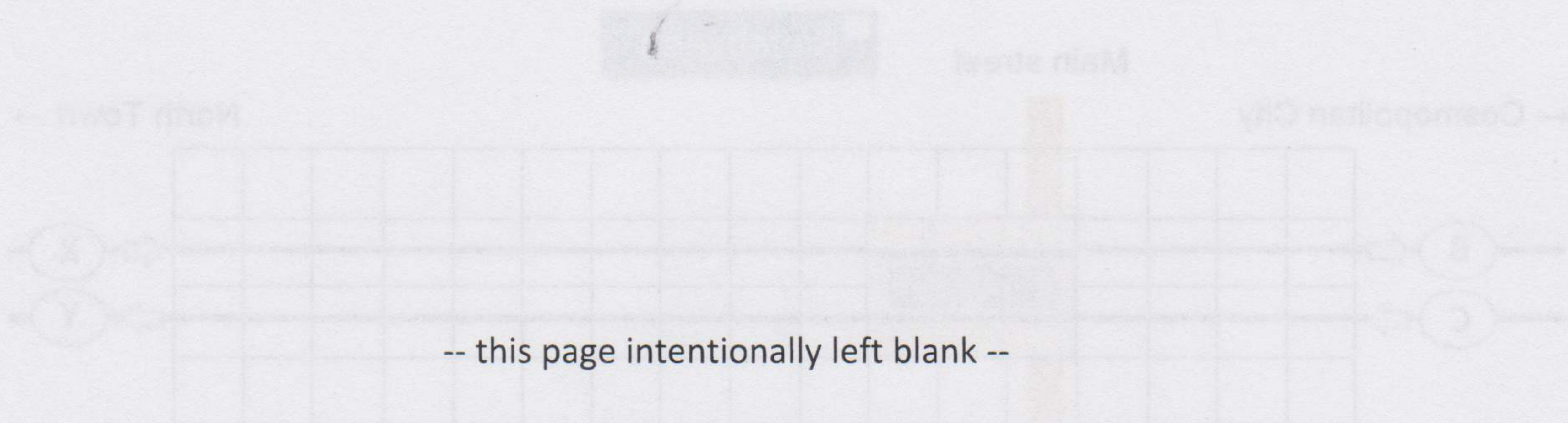
There are enough passengers (town B is more or less a suburb of the adjacent city A) so the passenger transport company is willing to do so.

The rail infrastructure network manager states that it is not possible without building new tracks.

- [2 points] The rail infrastructure network manager is right. Explain why.
- [4 points] Propose two possible solutions, not being extra tracks, that might help improve track capacity and describe why your solutions are valid.

Question 6 [13 points] Bietenvæn station

In 2017 Bietenvæn is just an intermediate stop along a line from Cosmopolitan City to North Town with every 12 minutes an all station service (Cosmopolitan City - North Town v.v.). Express / Intercity trains (also 4 trains per direction each hour Cosmopolitan City - North Town v.v.) just pass through.



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Situation station Bietenvæn 2017

In the coming years the town of Bietenvæn will become an important satellite town of the nearby Cosmopolitan City which has fast growing job opportunities. Plans are to triple the amount of buses in Bietenvæn. Meaning more commuters travelling every day between Bietenvæn and Cosmopolitan City. To facilitate this new demand for traffic, the line between Bietenvæn and Cosmopolitan City will be doubled from 2 to 4 tracks. This is necessary to facilitate the new line planning with every 12 minutes an all station service and Express / Intercity trains stopping in Bietenvæn. To create enough track capacity, trains running between Cosmopolitan City and Bietenvæn are separated by train type. All station services use the inner tracks (B and C). Express / Intercity trains use the outer tracks (A and D). Because there is no need for doubling the amount of all station services between Bietenvæn and North Town, 4 of the 8 all station services begin / end at Bietenvæn. To offer a smooth journey for commuters living in North Town and working in Cosmopolitan City the 4 Express / Intercity trains will have a cross platform change (in both directions) over at Bietenvæn making a connection to the 4 station services beginning / ending at Bietenvæn.

It is up to you to design the new station.

Specifications (additional to the ones in the text above):

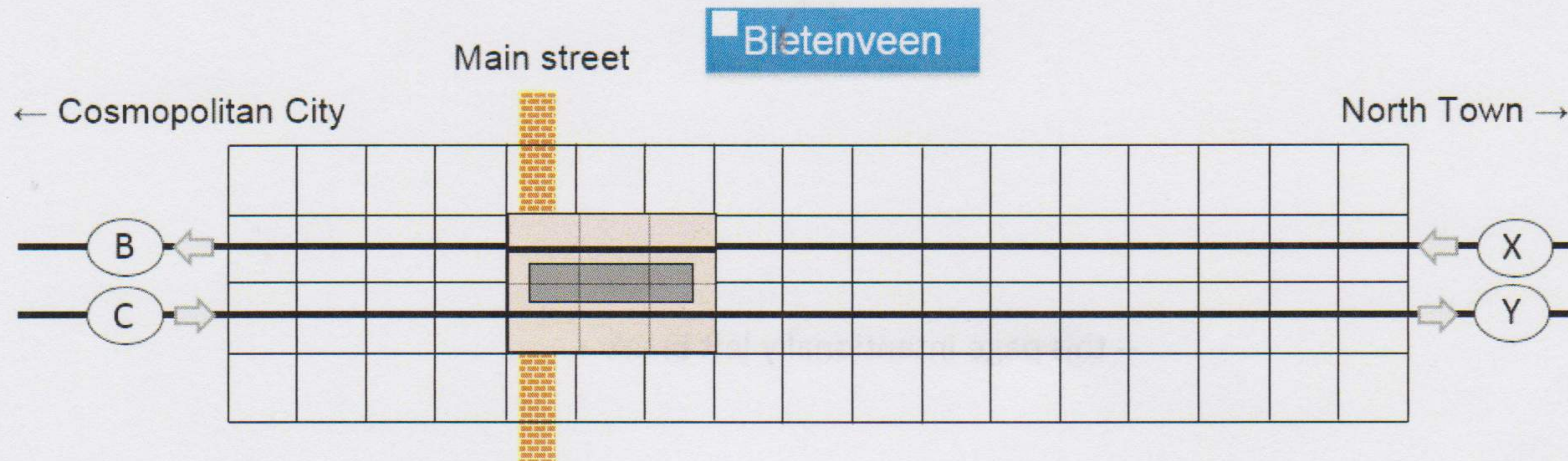
- The new station must be connected to 'Main street' (the platform must overlap Main street at some point).
- The process of turning around of all station services beginning / ending at Bietenvæn may not interfere with the Express / Intercity trains running from X to A and D to Y.
- Stay inside the checkboard.
- Use only standard elements (use as many as you need and rotate or mirror them if necessary).
- The element 'Buffer stop' is considered long enough to facilitate the longest all station service.
- Don't spend more money than necessary.

Note: there is an answer form attached to this exam.

Question 6 [13 points] Bietenveen station

In 2017 Bietenveen is just an intermediate stop along a line from Cosmopolitan City to North Town with every 15 minutes an all station service (Cosmopolitan City - North Town v.v.).

Express / Intercity trains (also 4 trains per direction each hour Cosmopolitan City - North Town v.v.) just pass through.



Situation station Bietenveen 2017

In the coming years the town of Bietenveen will become an important satellite town of the nearby Cosmopolitan City which has fast growing job opportunities. Plans are to triple the amount of houses in Bietenveen. Meaning more commuters travelling every day between Bietenveen and Cosmopolitan City.

To facilitate this new demand for traffic, the line between Bietenveen and Cosmopolitan City will be doubled from 2 to 4 tracks. This is necessary to facilitate the new line planning with every 7,5 minutes an all station service and Express / Intercity trains stopping in Bietenveen.

To create enough track capacity, trains running between Cosmopolitan City and Bietenveen are separated by train type. All station services use the inner tracks (B and C). Express / Intercity trains use the outer tracks (A and D).

Because there is no need for doubling the amount of all station services between Bietenveen and North Town, 4 of the 8 all station services begin / end at Bietenveen.

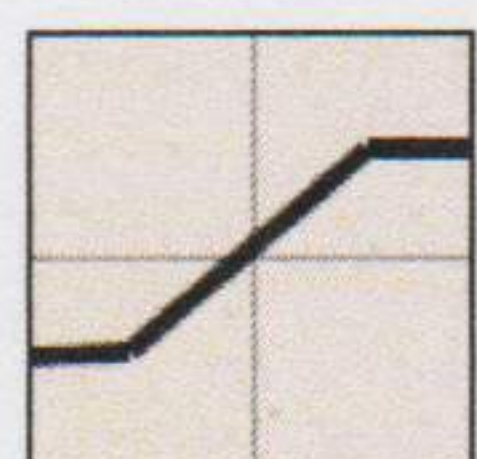
To offer a smooth journey for commuters living in North Town and working in Cosmopolitan City the 4 Express / Intercity trains will have a cross platform change (in both directions) over at Bietenveen making a connection to the 4 station services beginning / ending at Bietenveen.

It is up to you to design the new station.

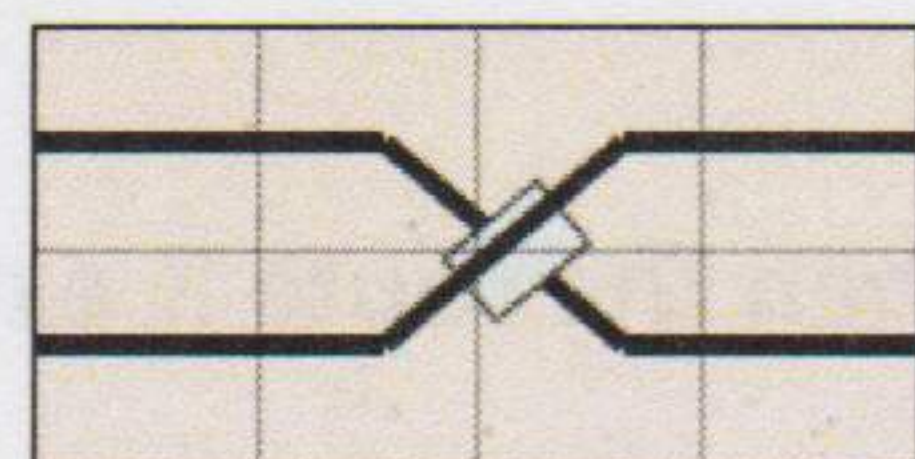
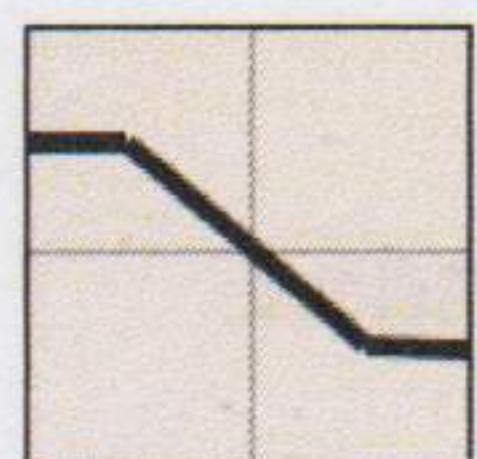
Specifications (additional to the ones in the text above):

- The new station must be connected to 'Main street' (the platform must overlap Main street at some point).
- The process of turning around of all station services beginning / ending at Bietenveen may not interfere with the Express / Intercity trains running from X to A and D to Y.
- Stay inside the checkerboard.
- Use only standard elements (use as many as you need and rotate or mirror them if necessary).
- The element 'Buffer stop' is considered long enough to facilitate the longest all station service.
- Don't spend more money than necessary.

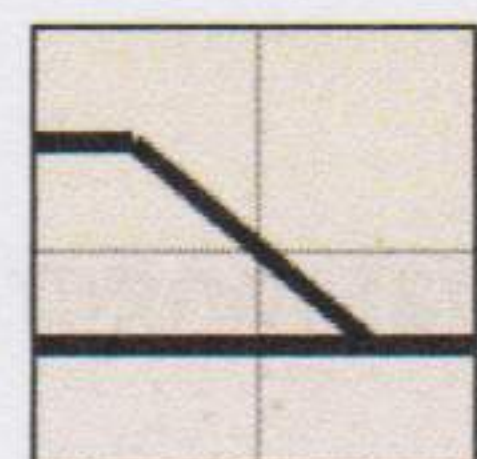
Note: there is an answer form attached to this exam.



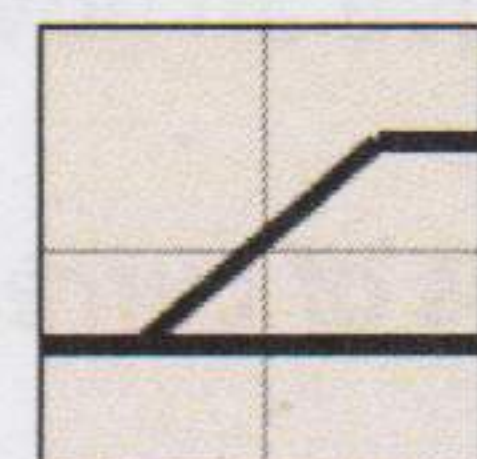
Curves
€ 5,-



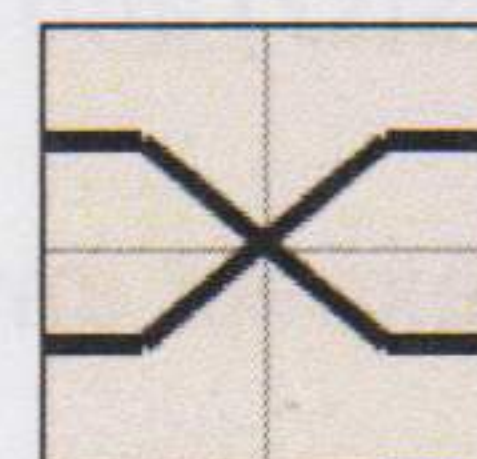
Fly over
€ 1000,-



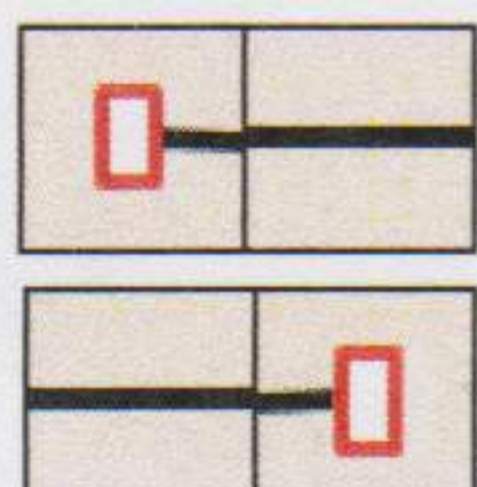
Point
€ 100,-



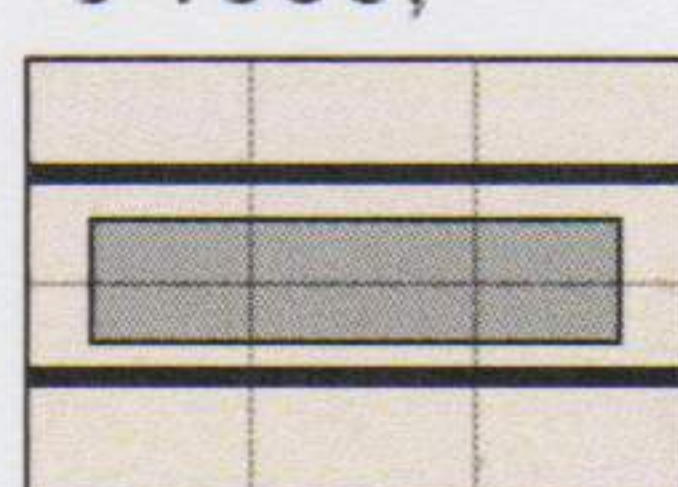
Diamond crossing
€ 100,-



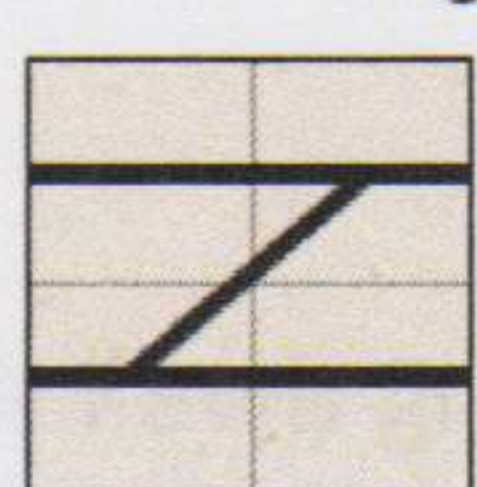
Straight track
Free!



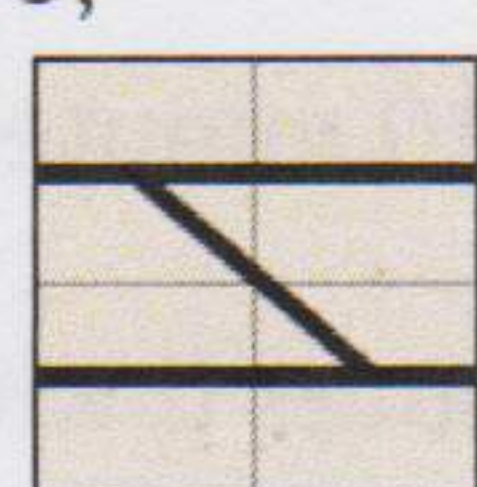
Buffer stop
€ 50,-



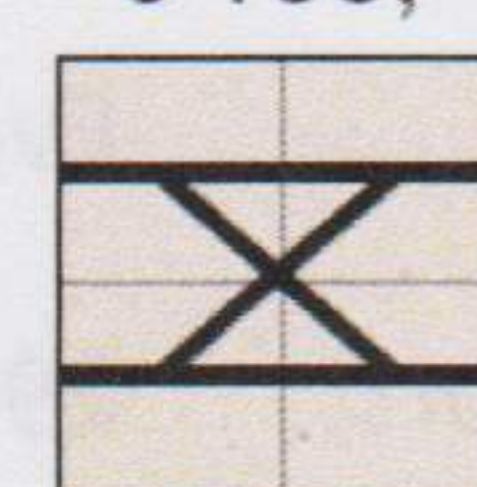
Platform
€ 500,-



Pair of points
€ 200,-



Scissors crossover
€ 550,-



Question 7 [20 points] Exploitation BRT Almere

The maps on the next page shows the new BRT-network for the city Almere. PT-authority Almere and Keolis (PT company) have a revenue-contract.

There are several requests from citizens to realize an extra stop at busstop 'Gooisekant West' for M4 (the yellow line) and then get back to the current route. This takes 2 minutes extra for each direction (including dwell time). As a professional transport consultant you are asked to advise the city of Almere. You are asked to determine what the breakeven point is (How many new passengers for a working day are needed to compensate the extra costs?) and to give an advise.

The city Almere doesn't expect any loss of current passengers when the route is extended.

Additional facts:

Headways: Every 10 minutes

Travel time Centrum-Poort: 29 minutes (including dwell time)

Travel time Poort-Centrum: 29 minutes (including dwell time)

The M4-busses ride between 06:00-23:00 (Monday to Friday)

The subsidy is € 40.00 per service hour

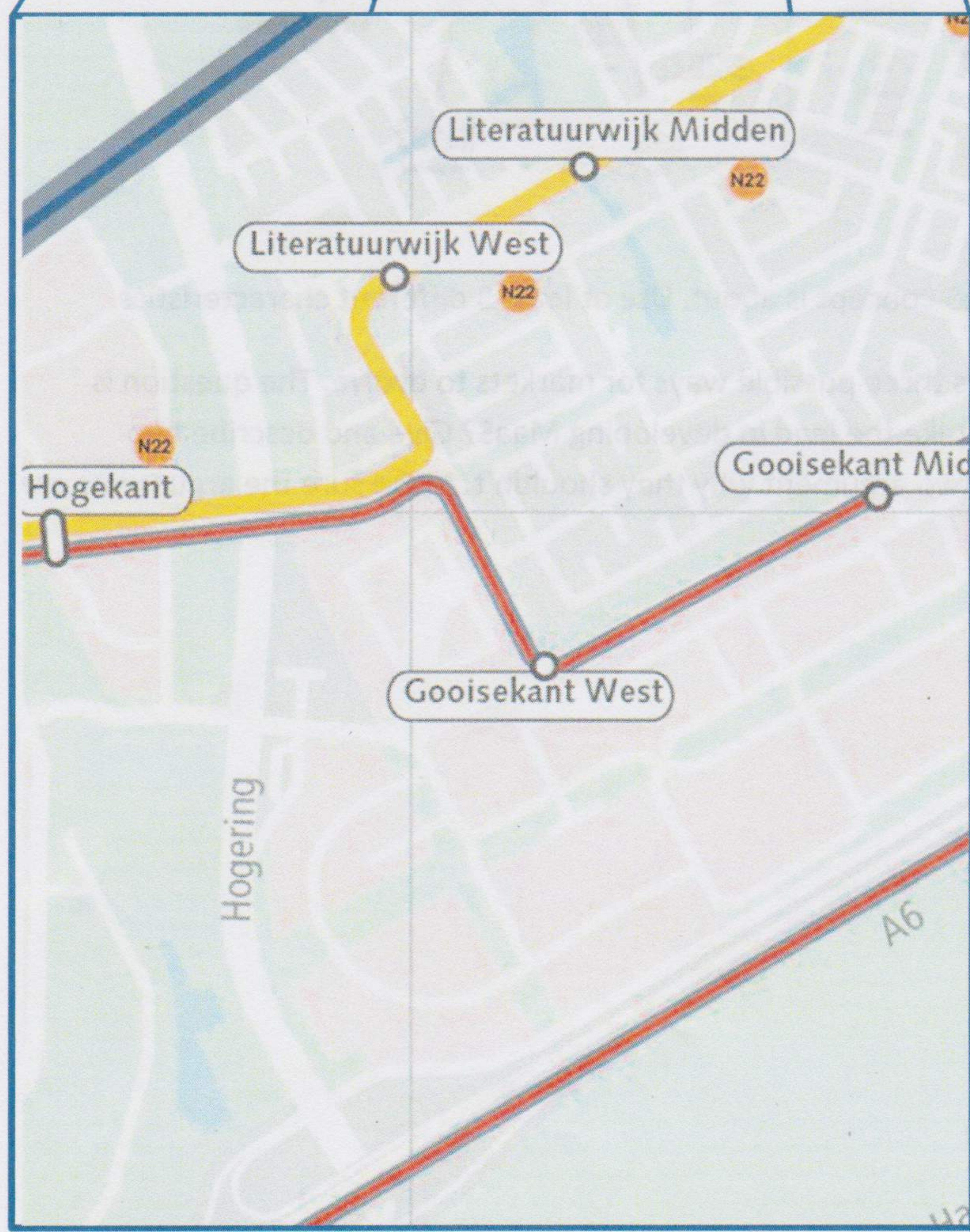
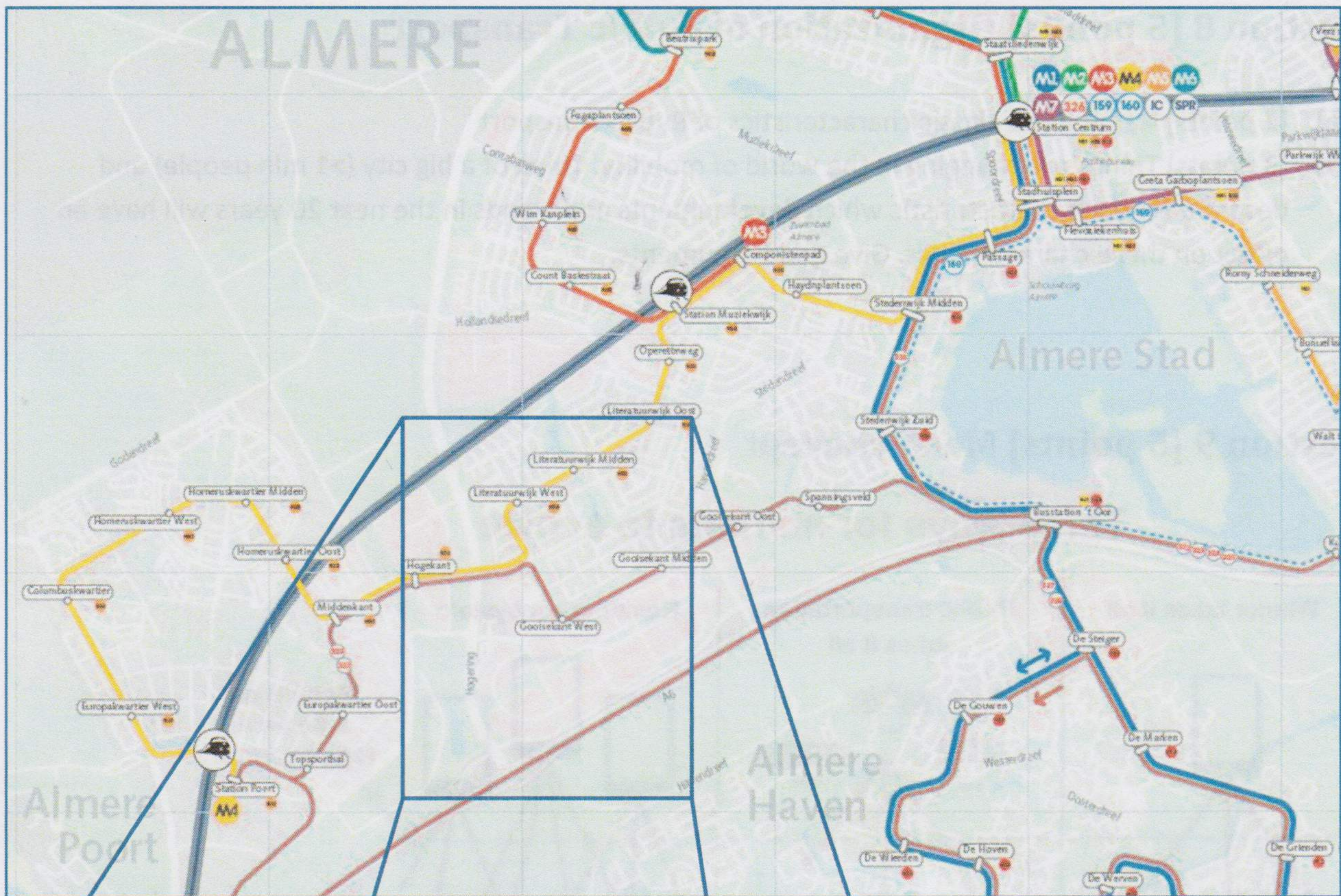
The average passenger revenue is € 60.00 per service hour

The average travel distance for M4 is 6 km

The revenues per traveled km are € 0.16

The boarding tariff per passenger is € 0.90

- [4 points] Calculate the number of busses needed in the current situation and when the extra bus stop is included.
- [4 points] Make a realistic time-way diagram for the current situation for M4 between 08:00 and 09:00 hour.
- [10 points] Calculate the breakeven point (new passengers needed) for including the extra bus stop for 2 scenario's:
 - The total subsidy for M4 from Almere stays the same
 - The subsidy for a service hour stays the same
- [2 points] Advise the city of Almere whether the extra bus stop is a good idea or not and why. Also make two suggestions for alternative idea's.

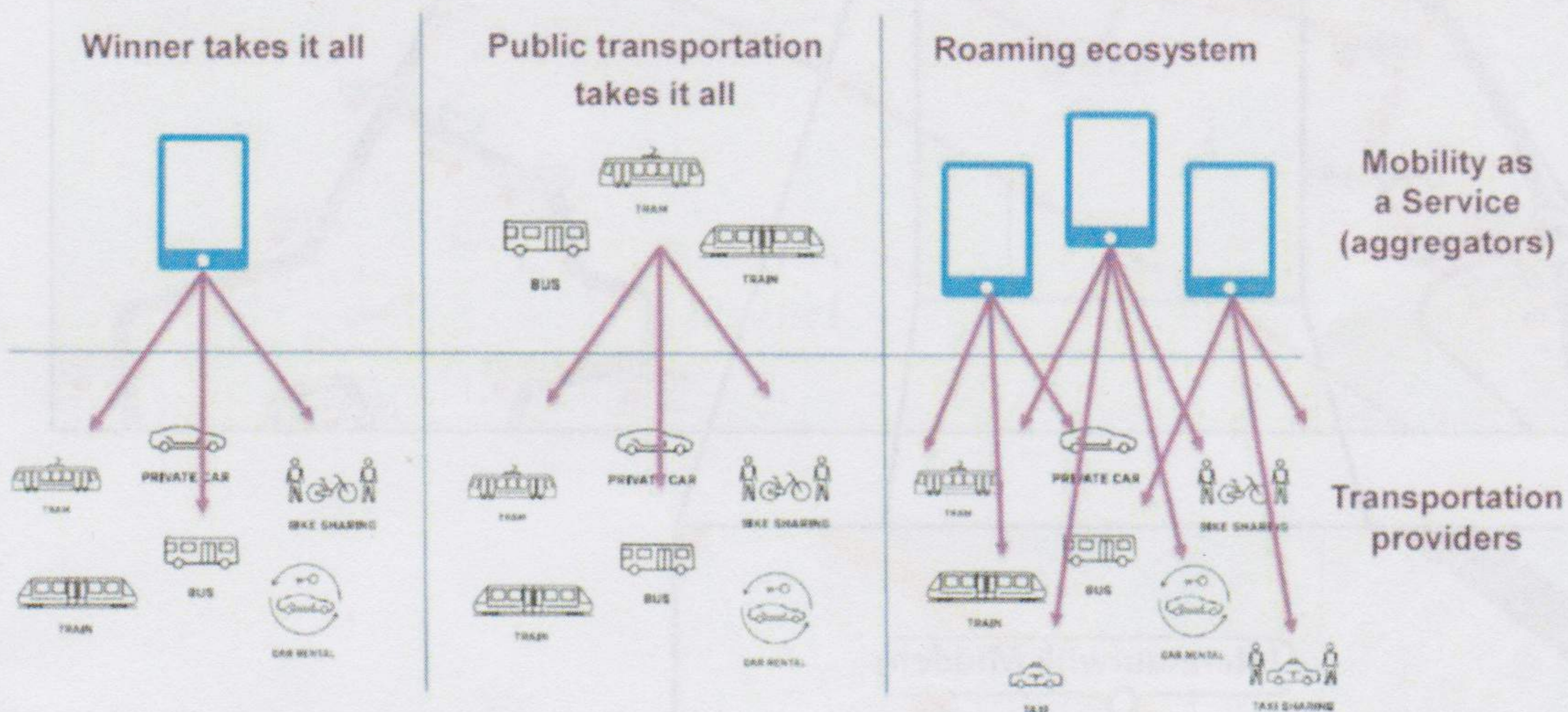


Question 8 [5 points] Organization of Public Transport

- [2 points] Name three classic characteristics of Public Transport
- [3 points] Things are changing in the world of mobility. Think of a big city (>1 mln people) and describe for each characteristic which developments and trends in the next 20 years will have an effect on these characteristics. Give good arguments.

Question 9 [5 points] MaaS-concept

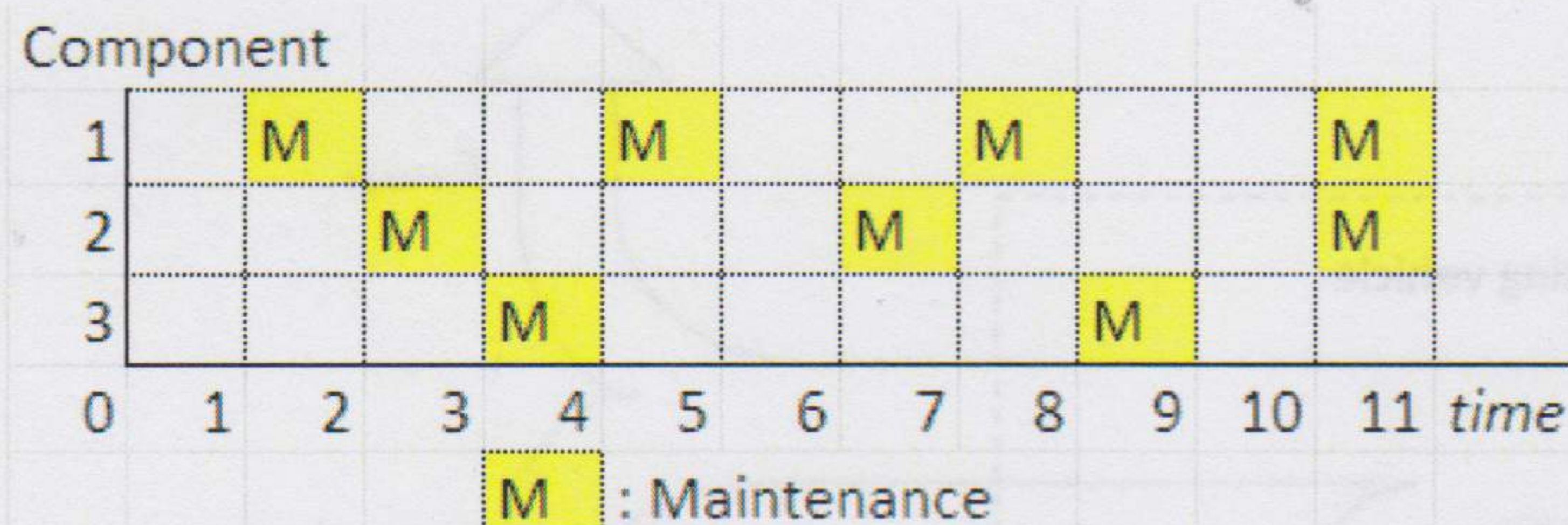
Three ways for markets to evolve



- [3 points] Describe what the MaaS-concept is about. Use at least 5 different characteristics.
- [2 points] The image above shows three possible ways for markets to evolve. The question is whether the government should take the lead in developing MaaS? Give and describe two arguments why they should and two argument why they shouldn't. Make sure the arguments are solid.

Question 10 [10 points] Rail maintenance

For the maintenance of a railway track consisting of 3 components the maintenance schedule shown in Figure 1 has been developed. The maintenance of the components is scheduled for the latest possible moment. The individual maintenance cost for the components (c_m), the costs for shortening the service-life of a component (c_s), the time needed to do the maintenance for each component (t_m), the available possession time for maintenance (t_p), and the cost of blocking the track for maintenance (c_p) are provided as well.

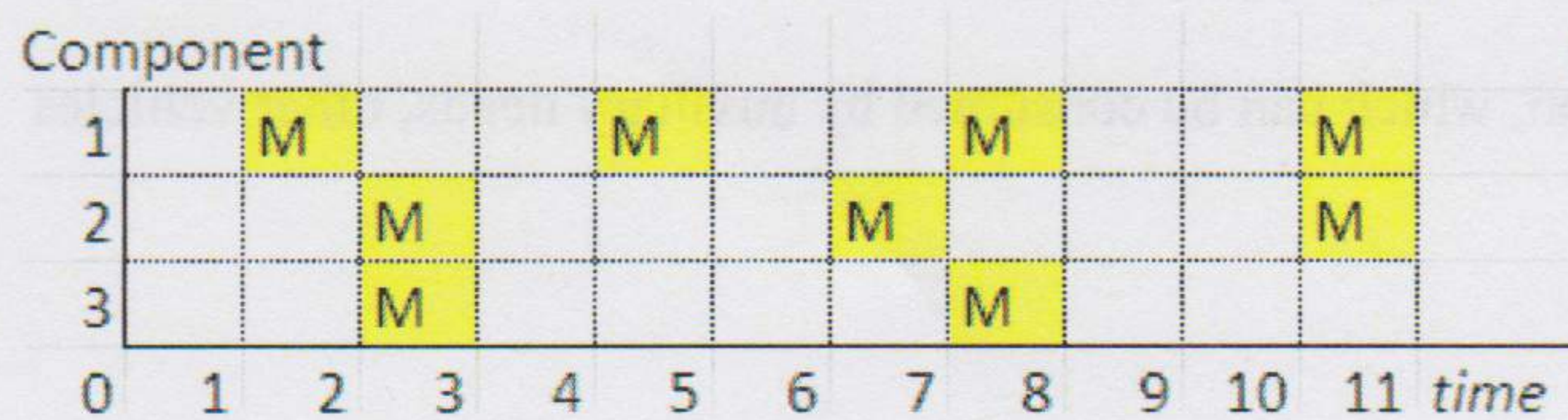


Component	c_m	c_s	t_m (hrs)
1	4	0,5	2
2	2	0,5	2
3	3	0,4	3

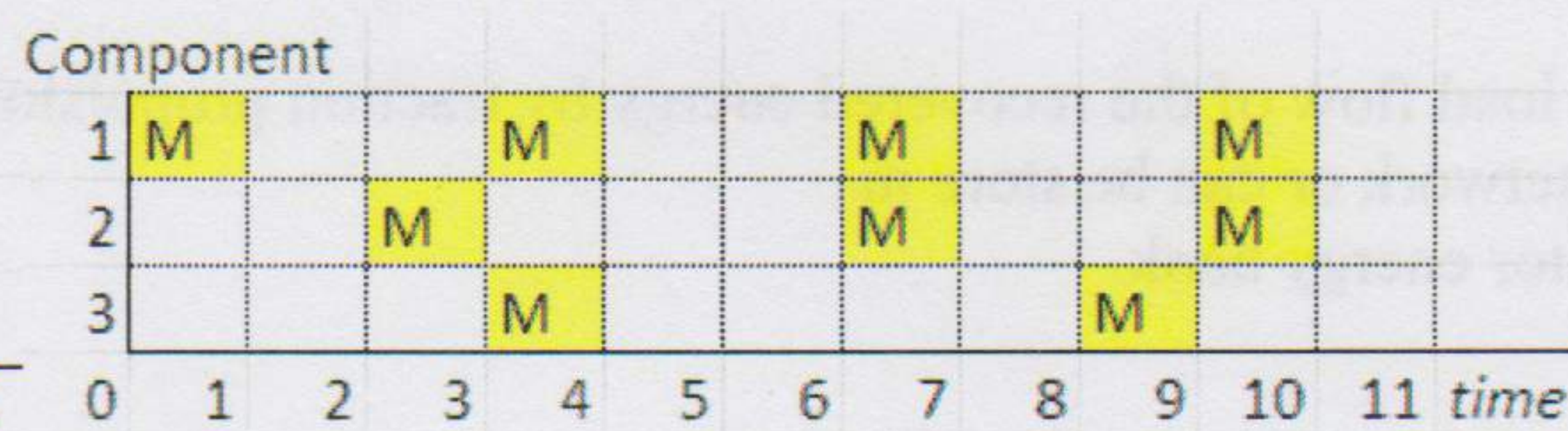
$C_p=1,5$; $t_p = 5$ hrs.

Fig. 1 Original schedule

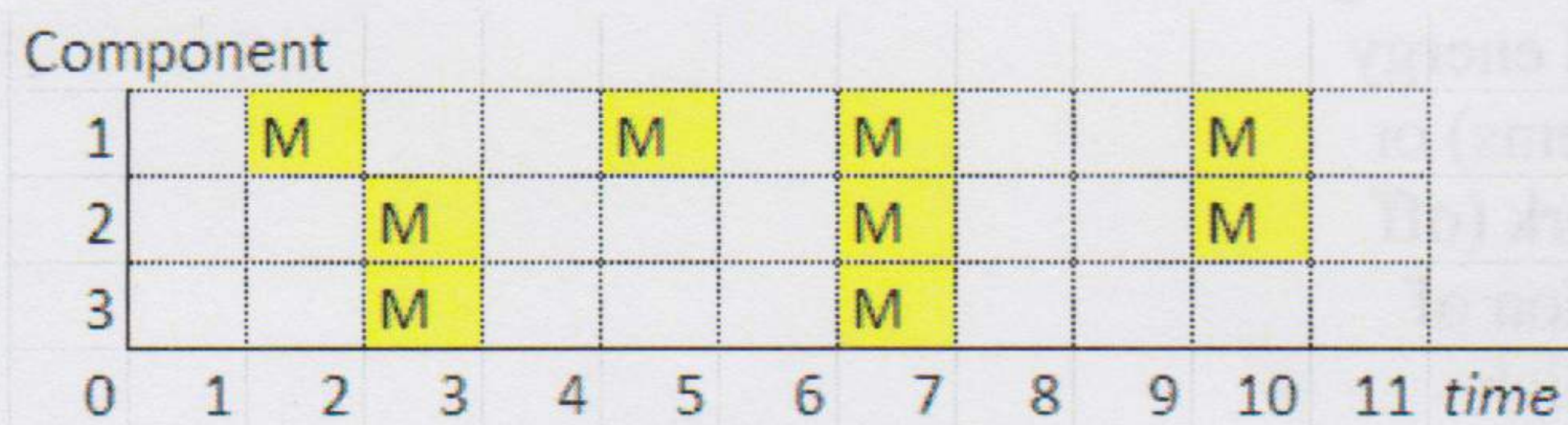
A maintenance planner suggests the following four alternative schedules:



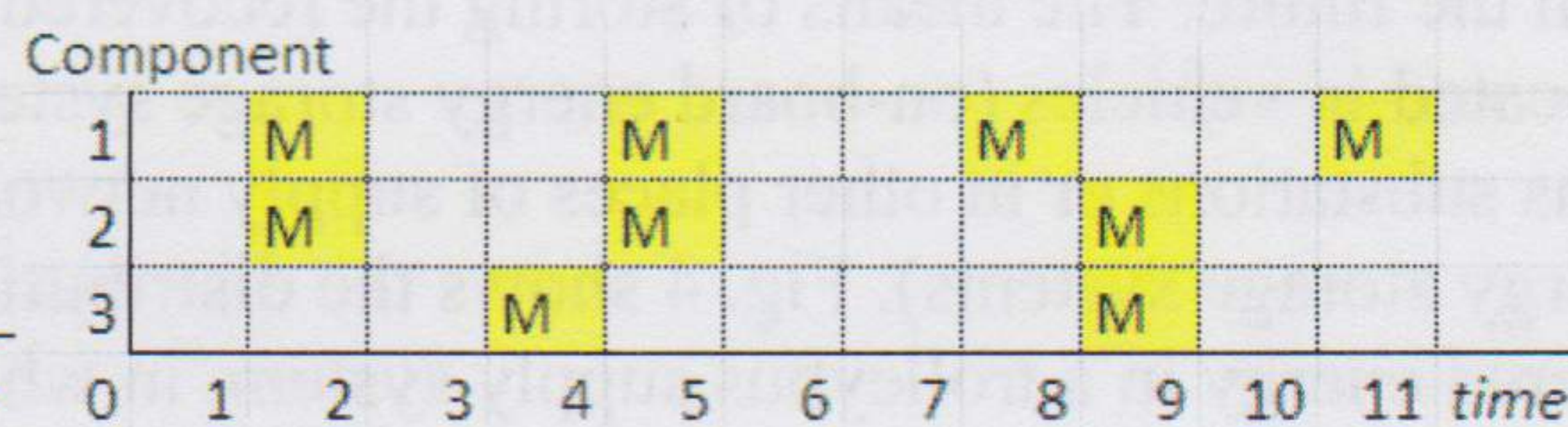
(A)



(B)



(C)



(D)

- [6 points] What are maintenance costs, possession costs, service-life shortening costs and total costs for the original schedule and the four alternative schedules?
- [4 points] Which schedule should be selected? Explain!

Question 11 [20 points] Recovered energy use

Below you find a quote from M. Bartłomiejczyk, M. Połom / Energy Conversion and Management 127 (2016) 35–42.

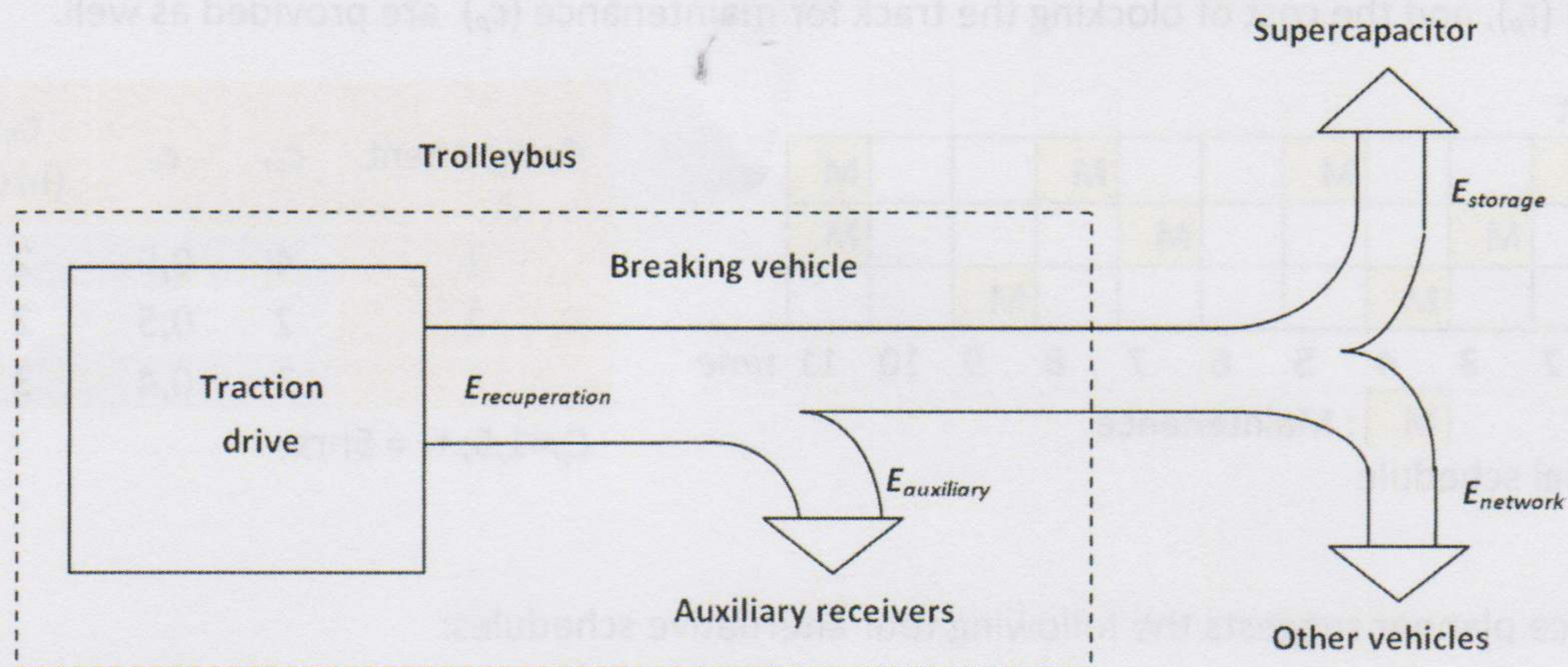


Fig. 4. The load flow of the recovered energy by traction propulsion, which can be consumed by auxiliary needs, other vehicles running in network or can be store in supercapacitor energy bank.

An alternative solution is to store the recovered energy in supercapacity energy storage systems to reuse it to power moving vehicles in the future. The means of storing the recovered energy may be located in vehicles (on-board energy storage systems) or in tractions substations or in other places of supply network (off board energy storage systems). Fig. 4 shows the distribution of the recovered energy in a trolleybus supply system, in which energy storage is installed in a traction substation. Part of the recovered energy $E_{recuperation}$ generated during regenerative braking is used to satisfy internal demand of the trolleybus (lighting, auxiliary drives, heating etc.) – and is marked as $E_{auxiliary}$. The remainder of the recovered energy is fed back to the contact system, in which it is partly absorbed by other vehicles in the supply area ($E_{network}$), with the remainder ($E_{storage}$) stored in an energy storage facility.

Recuperation energy balance may be described by the following equation:

$$E_{recuperation} = E_{auxiliary} + E_{network} + E_{storage} \quad (1)$$

- a) [10 points] In the quote an order in the use of recuperation energy is suggested. Is here a reasoning for a hierarchy in the use of recuperated energy? Explain why.

Below you find a figure from M. Bartłomiejczyk, M. Połom / Energy Conversion and Management 127 (2016) 35–42.

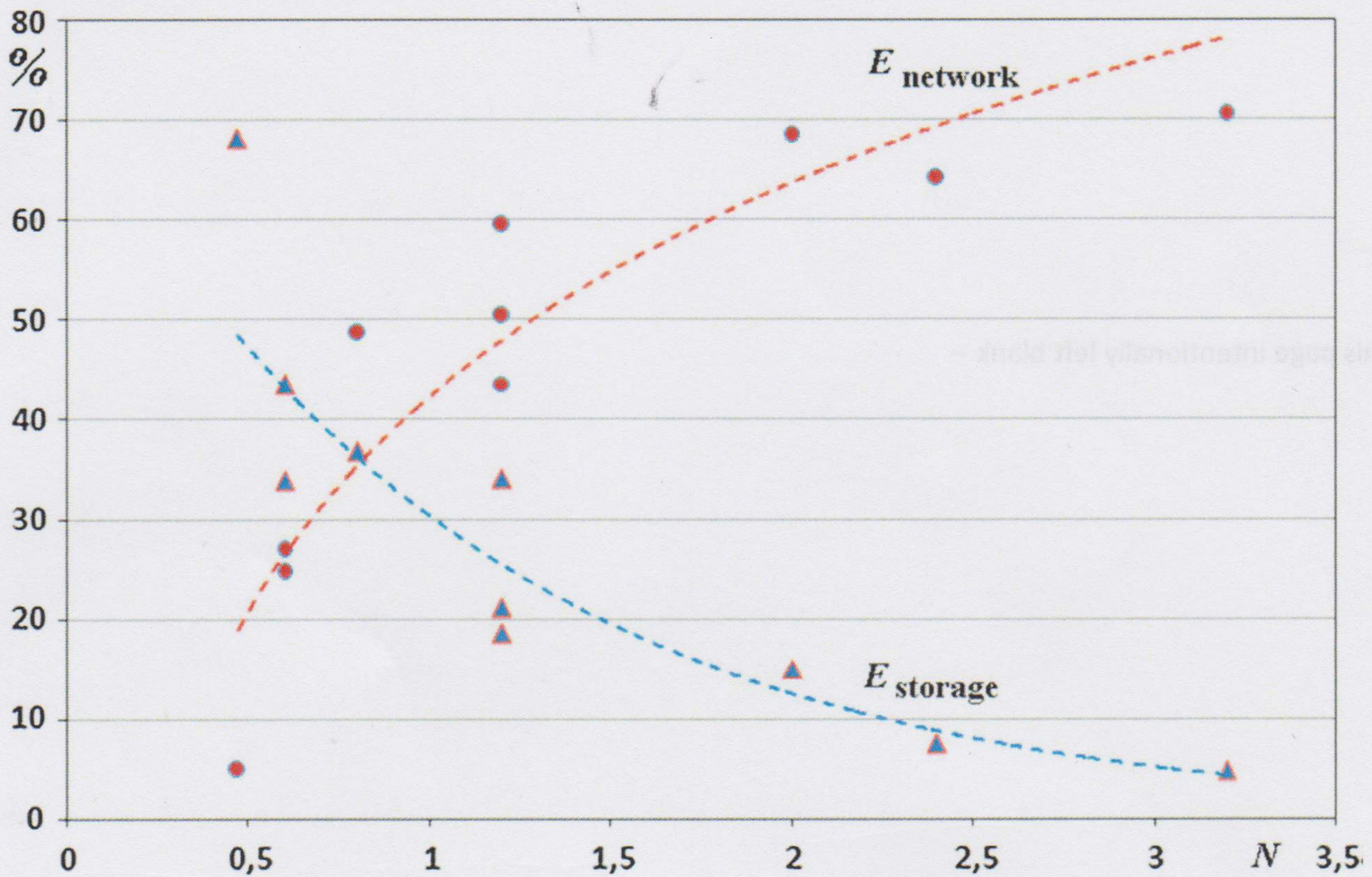


Fig. 11. Relation between the average number N of the vehicles, which express the density of trolleybus movement on the individual supply sections and the value of recuperated energy consumed by other vehicles E_{network} and recuperated energy stored in supercapacity bank E_{storage} referred to value of energy recuperated by propulsion E_{recovery} .

- b) [10 points] Explain why the storage of recuperated energy by propulsion (E_{recovery}) in a supercapacity bank (E_{storage}) decreases with the average number of vehicles (N) on the individual supply section.

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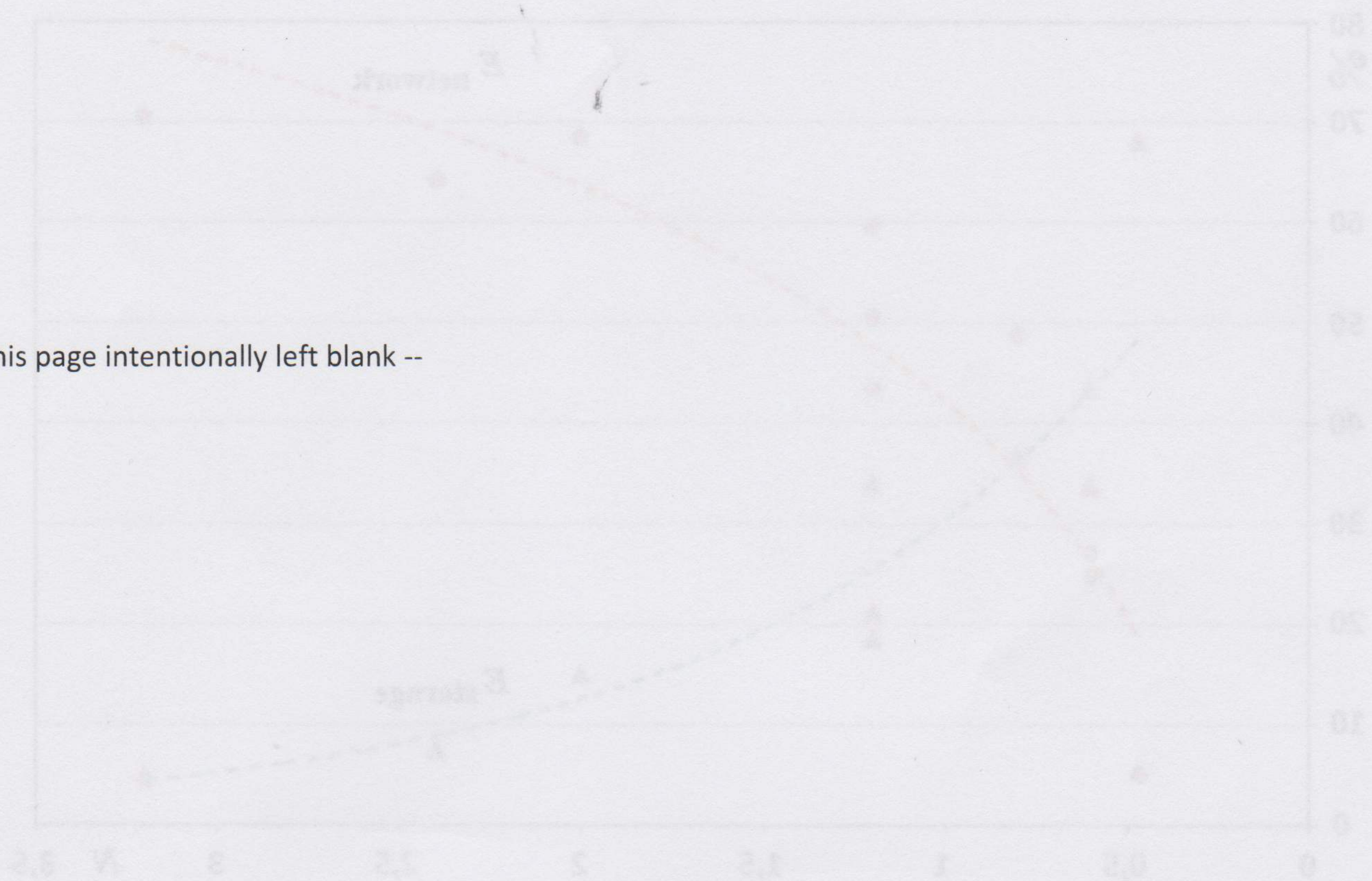


Fig. 11. Relation between the average number N of the vehicles, which express the density of vehicles movement on the individual supply section and the value of supercapacitor bank $E_{storage}$ related to value of energy requested by propulsion battery.

b) (10 points) Explain why the storage of recuperated energy by propulsion battery decreases with the average number of vehicles (N) on the individual supply section.

Appendix: Answering form for Question 6 Bietenveen station

Name: _____ Student number: _____

Bietenveen

Main street

North Town →

← Cosmopolitan City

Curves
€ 5,-

Fly over
€ 1000,-

Diamond crossing
€ 100,-

Scissors crossover
€ 550,-

Straight track
Free!

Pair of points
€ 200,-

Platform
€ 500,-

Buffer stop
€ 50,-