

# Written Exam Public Transport

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| Written Exam  | Public Transport (195421200-1A)                                                                                               |
| Teacher       | van Zuilekom                                                                                                                  |
| Course code   | 195421200                                                                                                                     |
| Date and time | 6-11-2014, 8:45-11:45                                                                                                         |
| Location      | RA 3334                                                                                                                       |
| Remarks       | Closed book, calculator allowed, English dictionary allowed<br>Formulas and tables are, when necessary, part of the question. |

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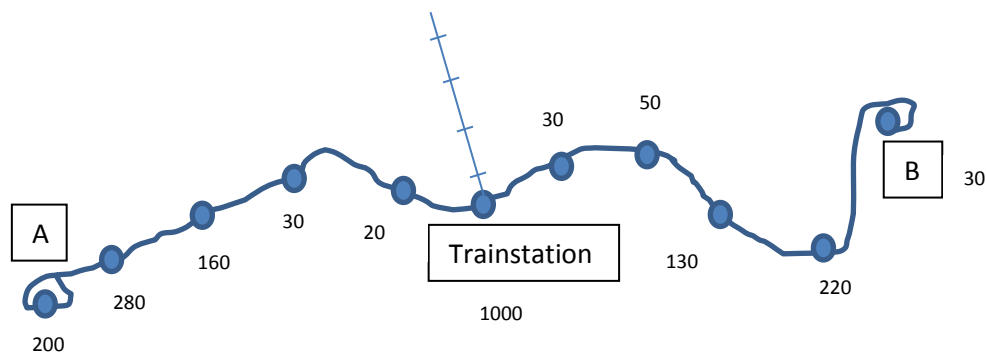
## *Calculation of the marks:*

- The maximum number of points of this written exam,  $P_{max}$ , is 100
- The marks for the written exam,  $C$ , is calculated by the sum of points,  $P$ , times ten divided by the maximum number of points:

$$C = 10 \cdot \frac{P}{P_{max}}$$

- Available time is 180 minutes (+ 25% for 'extra time students').

## Question 1 (16 points) – Building a Time Table



The image above is the visualisation of a city bus line from A to B (and back). The dots stand for the bus stops. For each bus stop the number of boarding passengers during a standard working day are given. Somewhere halfway the bus line there is a train station.

Some facts:

Circulation time Station-A-Station: 45 minutes

Circulation time Station-B-Station: 31 minutes

Walking time between train and bus: 3 minutes

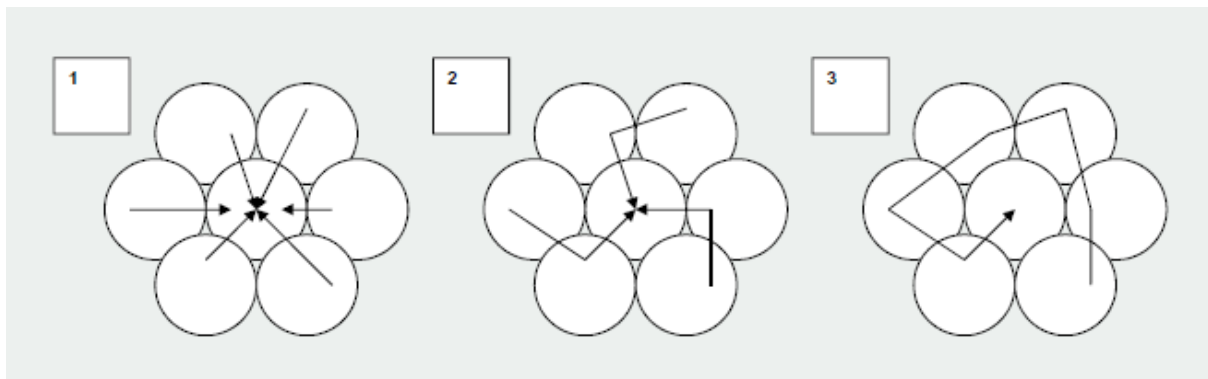
Trains arrive every hour at the train station/terminus at .29 and .59 and leave at .05 and .35.

The circulation times are excluding dwell time at train station, but including other bus stops.

As a professional transport planner you will have to take the following steps:

- (5 points) make an effective connecting diagram for train and bus (standard frequency of 2 busses/hour)
- (5 points) make a realistic time – way diagram for line A-B
- (3 points) calculate the number of busses needed for line A-B
- (3 points) make a proposal how to minimize the number of busses and make an estimation how it will affect the cost cover percentage

## Question 2 (6 points) – Public Transport and basic mobility



Basic mobility is all about the individual needs of passengers (door to door trips). The figure above shows three of the principles of routing. The circles are districts in a certain town and the arrows are routes with a taxi or small bus.

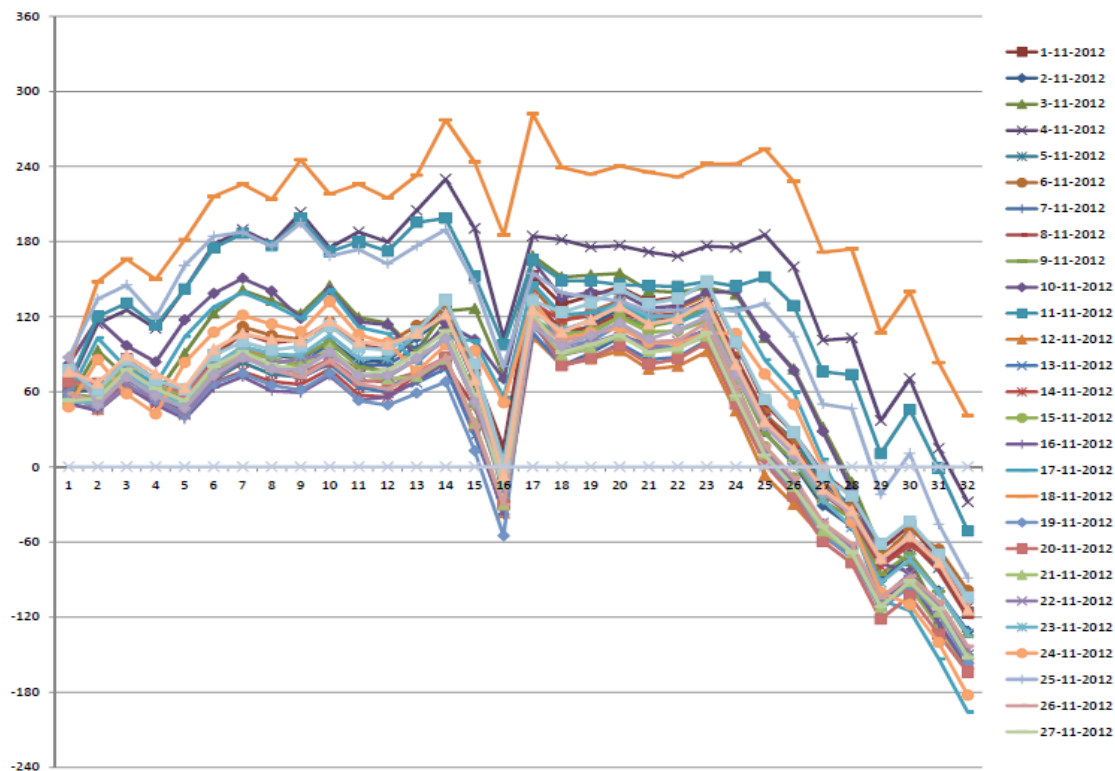
- (2 points) Name four different target groups for small-scale demand-responsive transportation
- (2 points) Describe the advantages and disadvantages of the three routing principles for passengers
- (2 points) Describe how and under what conditions regular public transport can play a role in providing passengers basic mobility

## Question 3 (6 points) – Data analysis

Big data is an all-encompassing term for any collection of data sets so large and complex that it becomes difficult to process using traditional data processing applications (wikipedia). It is evident that in the world of Public Transport the collection and application of data becomes more important too.

- (3 points) Describe two important and relatively new ways of data collection for Public Transport by bus in the Netherlands.
- (3 points) Describe at least 5 different ways how this data can be used to make a better offer for the passengers.

### Question 4 (10 points) – Exploitation and reliability



The line chart above shows the average difference between planned and actual departure time per stop per day for November 2012 for a specific bus line in one direction. On the X-axe you find the 32 stops of the bus line. The Y-axe shows the average difference between planned and actual departure time at the bus stop in seconds, where a positive value means too late and a negative value too early.

Calendar for November 2012:

| November 2012 |    |    |    |    |    |    |
|---------------|----|----|----|----|----|----|
| Mo            | Tu | We | Th | Fr | Sa | Su |
| 45            | 29 | 30 | 31 | 1  | 2  | 3  |
| 46            | 5  | 6  | 7  | 8  | 9  | 10 |
| 47            | 12 | 13 | 14 | 15 | 16 | 17 |
| 48            | 19 | 20 | 21 | 22 | 23 | 24 |
| 49            | 26 | 27 | 28 | 29 | 30 | 1  |
| 50            | 3  | 4  | 5  | 6  | 7  | 8  |

- (5 points) Name and explain at least three remarkable things in this line chart.
- (5 points) Describe three - in principle - different ways how to make Public Transport more reliable

### Question 5 (24 points) – Public transport assignment

Consider the following PT network, consisting of 1 origin, 1 destination, 3 access links, 1 egress link, 4 nodes / stops (A, B, C and D), 3 transit links and 3 transit lines (I, II and III). Transit line I calls at stop A and D and has frequency ( $F$ ) 4 per hour. Transit line II calls at stop B, C and D and has frequency 6 per hour. Transit line III calls at stop C and D and has frequency 6 per hour.

The travel times  $T$  of (access, egress and transit) links are given in the network (in minutes). Assume the dwell time (for line II) at stop C to be equal to 0. Stops A, B and C are within the search radius from the origin. Assume that transferring from transit line II to transit line III at stop B involves such a high transfer penalty, that it is not a choice option for the traveler.

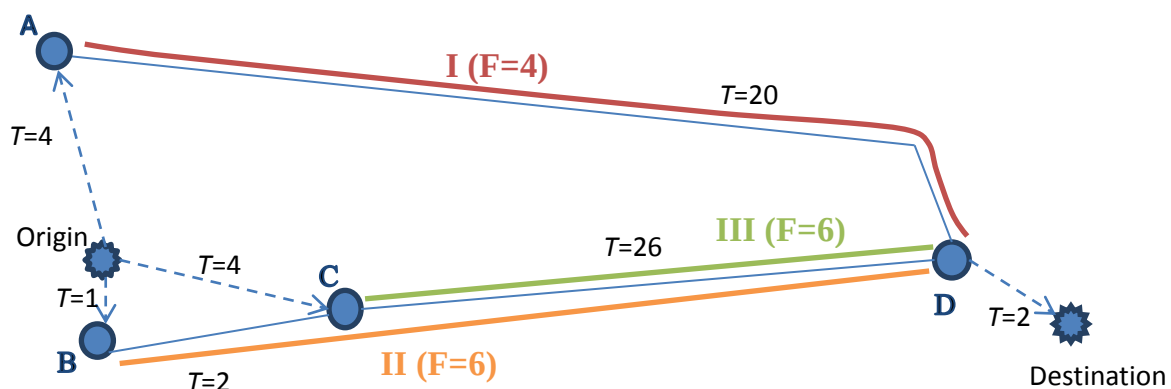


Figure 1 The PT network

This transit network results in 4 routes being used by the travelers (if a different line is used this is considered as a separate route).

a) (20 points) Calculate the fractions for the use of each route for this OD pair. For that, take the following into account:

- Calculate the generalized costs in time units (minutes), assuming that waiting time has a 30% higher weight than in-vehicle travel time (factor 1.3). Access / egress travel time is equally weighted as in vehicle time. Other cost components (like distance or fare) are not considered in this question.
- Calculate the waiting time at stops by assuming that passengers arrive completely random at the stop and that the transit services run completely reliable with equal headways.
- Use the choice models within the Zenith algorithm: the formulas are given below. The stop choice parameter ( $\theta$ ) is 0.2 and the access service choice parameter ( $\lambda$ ) is 0.1.

b) (4 points) Explain in words what would happen to the route fractions calculated in a) if waiting time would have been weighted more strongly (i.e. the weight factor for waiting time would be higher than 1.3)

*All formulas necessary for this question you will find on the next page.*

Formula for stop choice:

$$P_s = \frac{e^{-\theta C_s}}{\sum_{x \in S} e^{-\theta C_x}}$$

Where:

$P_s$ : fraction for stop  $s$

$C_s$ : generalized costs when using stop  $s$

$S$ : set of candidate stops at the origin

$\theta$ : stop choice parameter

Formula for service choice (= line choice):

$$P_l = \frac{F_l e^{-\lambda C_l}}{\sum_{x \in T} F_x e^{-\lambda C_x}}$$

Where:

$P_l$ : fraction for line  $l$

$F_l$ : frequency of line  $l$

$C_l$ : generalized costs when using line  $l$

$T$ : set of candidate lines at the stop

$\lambda$ : service choice parameter

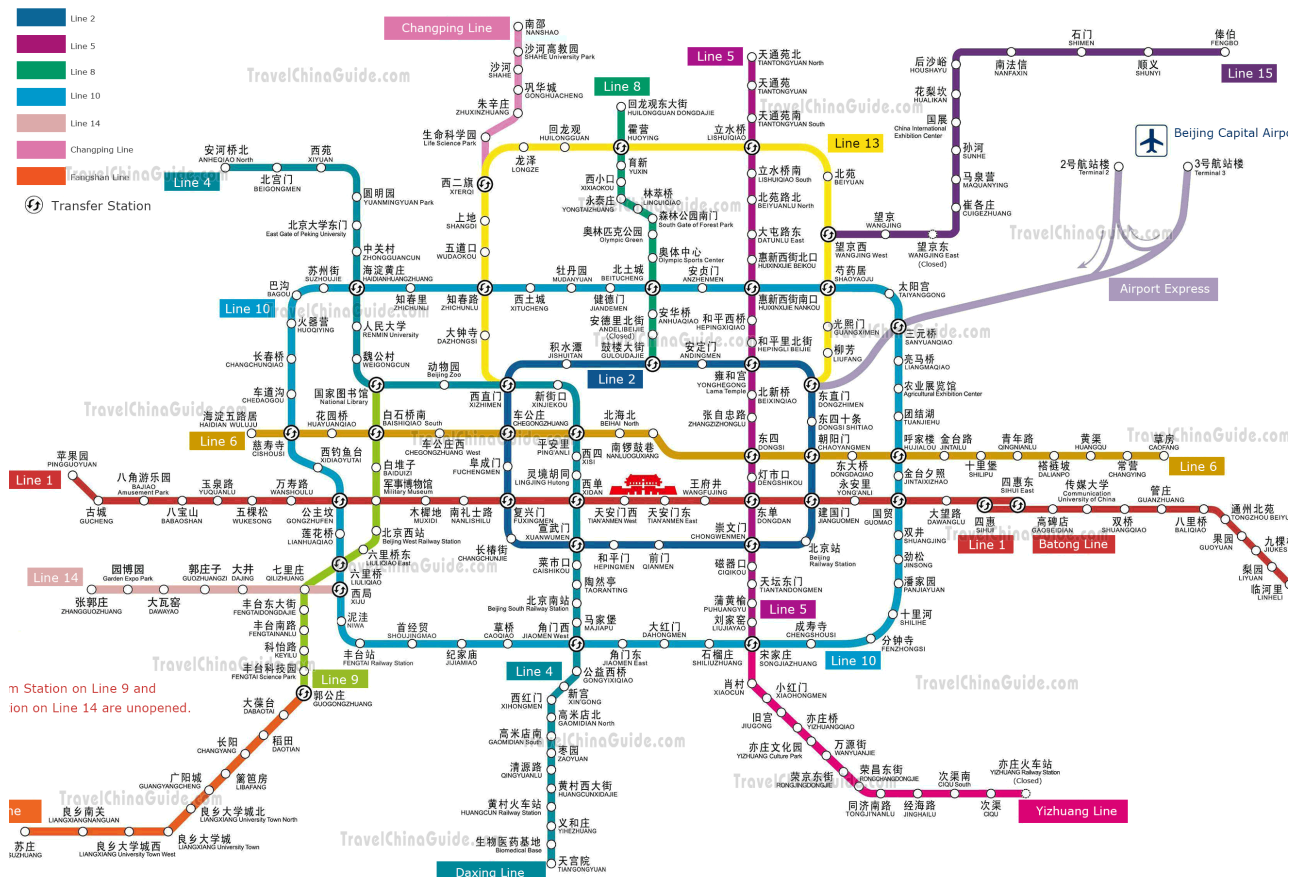
## Question 6 (6 points) – Lines and networks

See the metro map of Beijing below.

- a) (4 points) Name the types of the following lines:

Line 1, line 2, line 4, line 5, line 6, line 8, line 9 and line 10.

- c) (2 points) Does the network consist of independent or of integrated lines?



Note: Colour-blind are allowed to ask assistance in interpretation of the colours in the map.

### Question 7 (12 points) – approaches used for demand estimates / forecasts

Elasticity, trip end, and discrete choice are three (model) approaches used for demand estimates / forecasts in public transport.

- a) (2 points) Give the definition of elasticity.
- b) (10 points) For each approach, provide a case for which that approach is (best) suited. Motivate your answer.

### Question 8 (6 points) – selected link analysis

A selected link analysis can be used to estimate the potential for a new rail track.

Explain the concept of a selected link.

### Question 9 (14 points) – mass and regenerative braking

In 'A systems approach to reduce urban rail energy consumption' González-Gil et al. state:

*'The ratio of the traction energy saving percentage over the mass reduction percentage is estimated to be about 0.6–0.8 for urban rail, although it may be slightly lower when using regenerative braking.'*

The authors don't show why '*... it [the energy saving percentage] may be slightly lower when using regenerative braking.*'

What is the reasoning behind this statement? Is the statement plausible? Document the necessary assumptions explicit.