

Answers Written Exam Public Transport

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 Formulas and tables are, when necessary, part of the question.

Contents

Question 1 – Building a Time Table	2
Question 2 – Public Transport and basic mobility	3
Question 3 – Data analysis	3
Question 4 – Exploitation and reliability	3
Question 5 – Public transport assignment	5
Question 6 – Lines and networks	5
Question 7 – approaches used for demand estimates / forecasts	6
Question 8 – selected link analysis	6
Question 9 – mass and regenerative braking	6

Calculation of the marks:

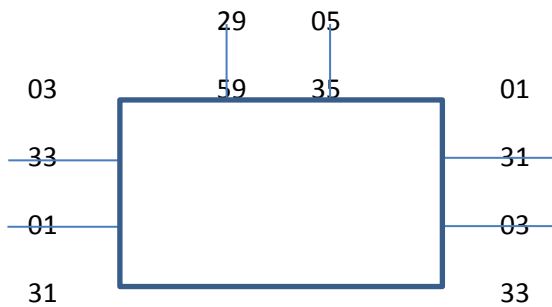
- The maximum number of points of this written exam, P_{max} , is 100
- The marks for the written exam, C , is calculated by the sum of points, P , times ten divided by the maximum number of points:

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

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

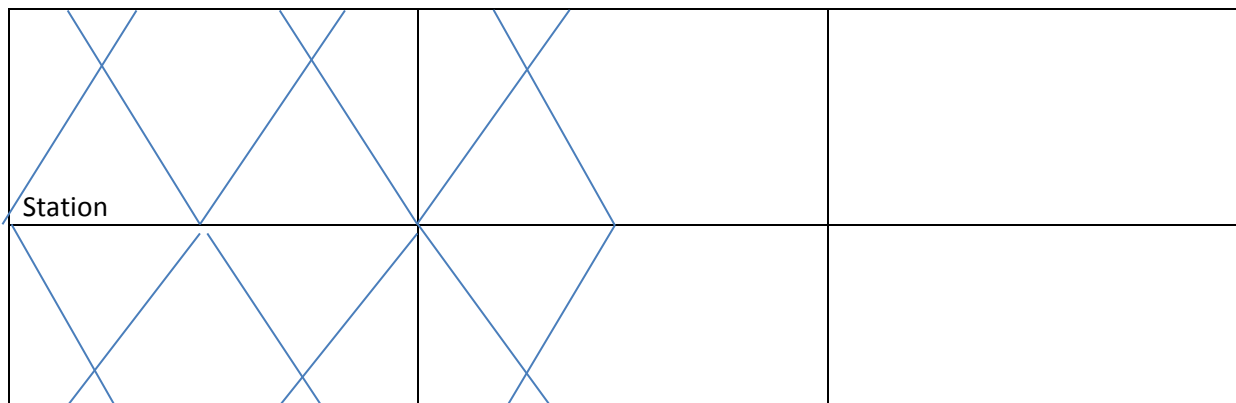
Question 1 – Building a Time Table

a. connecting diagram (5 points)



b. time-way diagram (5 points)

A



B

c. number of busses (3 points)

A-Station: $45/30 = 1,5 \rightarrow$ 2 busses

B-Station: $31/30 = 1,03 \rightarrow$ 2 busses

Total: 4 busses

d. minimizing busses (3 points)

delete the last bus stop on B (just 30 passengers) – the circulation time will drop <30 minutes

you will spare one bus B-Station: $27/30 = 0,9 \rightarrow$ 1 bus – total 3 busses

effect on the costcover: from 2150 passengers to 60 ($2 \cdot 30$) less: 1950 passengers $\rightarrow$ revenues:
 $1950/2150 = 0,91$

costs will drop: one bus and driver less - about 25% = 0,75 costcover: 50% $50/100 \rightarrow$ new costcover:
 $(0,91 \cdot 50)/(0,75 \cdot 100) = 45,5/75 = 61\%$

Question 2 – Public Transport and basic mobility

a. four target groups (2 points)

- Disabled elderly
- Handicapped, emotional, physical, intellectual
- Students, handicapped or belief
- Sheltered workshop
- Everybody

b. advantages and disadvantages (2 points)

1. + short direct routes, individual transport, small delays
- high costs (authority and probably passengers), competition PT
- 2 in between – so maybe acceptable – development to 1 or 3 (if necessary)
- 3 + low costs (auth/pass), PT more attractive
- long trips, combined other people, delays

c. how and conditions

PT – accessible for target groups: low floors, bus stops, help if needed, special apps, etc...

Question 3 – Data analysis

a. two ways of data collection

1. GPS –based system data meant for real-time dynamic travel information
2. PT-chipcard data

b. 5 different ways

line analysis - producing better and more reliable timetables
 - more efficient circulations – cheaper and faster
 - detecting bottlenecks in network and solutions
 - deleting not-used bus stops

Origin – destination – making a better network

Target groups – providing special offers

Easy evaluation marketing offers

Question 4 – Exploitation and reliability

a. three remarkable things (5 points)

1. busses leaving too late
2. on all stops too late
3. too early on last stop
4. on Sundays too late – other timetable (taking faster routes into account)
5. bus stop 16 is more on time – this is probably a stop where you have to wait to leave exactly on time

b. three way to make PT more reliable (5 points)

1. operational traffic management
2. dedicated infrastructure (fe bus lanes)
3. better, reliable and dynamic travel information
4. short distance radio for traffic lights
5. less stops
6. shorter lines

.....

Question 5 – Public transport assignment

- A) Line fractions at stop C can be calculated using the formula, using the costs (=travel times) when leaving stop C: (the lines have equal properties, so the formula does not have to be used: just fractions of 50%)

- 28 minutes in line II
- 28 minutes in line III

This includes 2 minutes of egress time

- $P_{II} = \frac{F_I e^{-\lambda C_I}}{\sum_{x \in T} F_x e^{-\lambda C_x}} = \frac{6e^{-0.1 \cdot 28}}{6e^{-0.1 \cdot 28} + 6e^{-0.1 \cdot 28}} = 0.5$
- $P_{III} = 1 - P_{II} = 0.5$
- Average travel time when leaving stop C is (using the fractions) $0.5 \cdot 28 + 0.5 \cdot 28 = 28$ minutes, also a waiting time of $60/12/2 = 2.5$ minutes and access time of 4 minutes, gives total generalized costs of $1.3 \cdot 2.5 + 4 + 28 = 35.25$ minutes
- Waiting time when using stop A: $60/4/2 = 7.5$ minutes. Generalized costs when using stop A: $1.3 \cdot 7.5 + 4 + 20 + 2 = 35.75$ minutes
- Waiting time when using stop B: $60/6/2 = 5$ minutes. Generalized costs when using stop B: $1.3 \cdot 5 + 1 + 28 + 2 = 37.5$ minutes
- Applying the formula for stop choice using these generalized costs results in fractions of 35.6%, 25.1% and 39.3% respectively for stop A, B and C:

$$P_A = \frac{e^{-0.2 \cdot 35.75}}{e^{-0.2 \cdot 35.25} + e^{-0.2 \cdot 35.75} + e^{-0.2 \cdot 37.5}} = 0.356$$

$$P_B = \frac{e^{-0.2 \cdot 37.5}}{e^{-0.2 \cdot 35.25} + e^{-0.2 \cdot 35.75} + e^{-0.2 \cdot 37.5}} = 0.251$$

$$P_C = 1 - P_A - P_B = 0.393$$

- At stop C two routes are distinguished (2 different transit lines), so the final distribution among routes becomes:

Route 1 (stop A, line I)	35.6%
Route 2 (stop B, line II)	25.1%
Route 3 (stop C, line II)	19.7%
Route 4 (stop C, line III)	19.7%

b) The routes with higher waiting time become less attractive and therefore receive a smaller fraction of travellers. In this case stop A / route 1 will have less passengers and routes 3/4 / stop C will have more passengers. Route 2 is in between and probably has a comparable fraction.

Question 6 – Lines and networks

- a)
- Line 1: Diametrical (transverse, through)
 - line 2: Circumferential / ring (circle)
 - line 4: Diametrical (transverse, through)
 - line 5: Diametrical (transverse, through)
 - line 6: Diametrical (transverse, through)
 - line 8: Radial
 - line 9: Tangential
 - line 10: Ring (circle)
- b) Independent lines

Question 7 – approaches used for demand estimates / forecasts

- a. $e_x = \frac{\Delta y/y}{\Delta x/x}$ with y the demand and x an attribute influencing the demand. In words: the elasticity is the ratio between the relative change in demand and the relative change in the corresponding attribute value.
 - b. - Elasticity: estimate of the relative change in demand due to the relative change in a dominant attribute like travel time and travel cost. The estimate is mainly valid for an average situation. For example: “a decrease in travel time of 10% will on average lead to an increase in demand of 10%”.
 - trip end: suitable to estimate the demand for a future stop train station, i.e. for an isolated PT attraction point.
- Discrete choice model: Demand estimates for competing modes in specific situations (i.e. for specific origin-destination (OD) relations). Also suitable for including changes in several attributes at the same time, including less dominant attributes.

Question 8 – selected link analysis

A selected link analysis shows the number of trips per OD relation traversing the selected link. It is thus providing information about which travelers, i.e. based on their origin and destination, are using a certain link.

Question 9 – mass and regenerative braking

Several approaches are possible. Ideally ‘the energy basics’ of the lecture are used extensive (and correct!). But first of all it important to interpret the quote correct.

‘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 first part of the quote (*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*) means that if the weight of a train is reduced with 1% the energy consumption of the vehicle will be reduced in a range of 0.6 to 0.8%. In fact this is the ‘price’ elasticity of energy saving over mass.

What does the second part of the quote (*although it may be slightly lower when using regenerative braking*) mean? For trains with recuperation this price elasticity is the same as for trains without recuperation, but there is a weak indication (*‘although it may be’*) this price elasticity is a bit (*‘slightly’*) lower. This means that if the weight of a train with recuperation is reduced with 1% the energy consumption of the vehicle will be reduced in a range of 0.6 to 0.8%, but perhaps a bit lower.

This means that the question is in fact: are there arguments why this price elasticity (energy saving over mass) is different for trains without and with recuperation facilities.

The propulsion force at the wheel is a result of hill, acceleration, roll and air resistance:

$$F_w = F_{hill} + F_{acc} + F_{roll} + F_{air}$$

Apart from the air resistance all are proportional to mass:

$$F_w = m \cdot (\alpha_{hill} + \alpha_{acc} + \alpha_{roll}) + F_{air}$$

Where α stands for the coefficients of hill, acceleration and rolling resistance.

The roll and air resistance are irreversible losses. It is not possible to recuperate them.

To calculate the energy need at the wheel we have to calculate the propulsion forces for every time step Δt :

$$W_{t+\Delta t} = F_{w,t} \cdot s_{\Delta t}$$

Suppose we are able to reduce the weight of a vehicle with a factor k . This will have a direct influence on the propulsion force and the energy need on the PT route. As the proportion of the air resistance in the total resistance is small for trains it is not strange that the influence of weight reduction has a large influence on the energy reduction (0.6-0.8 for urban rail). But does recuperation have influence on this elasticity?

Recuperation is only possible on top of the gliding/coasting deceleration:

$$W_{recup,t+\Delta t} = k \cdot m \cdot (a_{brake,t+\Delta t} - a_{glide,t+\Delta t}) \cdot s$$

The braking deceleration is bound by comfort and therefore not to be influenced. If a reduction of the mass has no influence on the gliding deceleration the relative share of the recuperation will not change. But if reduction of the mass influences the gliding deceleration then the relative share will change.

The deceleration of the vehicle at a constant speed v will be $\frac{F_{w,v}}{m}$ when propulsion stops. We estimate the average gliding deceleration to standstill by the average propulsion force :

$$a_{glide} = \frac{1}{2} \cdot \frac{F_{w,v}}{k \cdot m} = \frac{1}{2} \cdot \frac{k \cdot m \cdot \alpha_{roll} + F_{air}}{k \cdot m} = \frac{1}{2} \cdot \alpha_{roll} \cdot \frac{F_{air}}{k \cdot m}$$

This would mean that reduction of the mass would lead to a greater gliding deceleration. As a result the recuperation potential decreases absolute and relative. In practice the actual recuperation is only a proportion of the potential recuperation. This means that the net result of a weight reduction is positive although the relative contribution of recuperation will be less. This means that the statement made by González-Gil et al. is plausible.