

Prof. Michel Bierlaire

Cours: Introduction to transportation systems



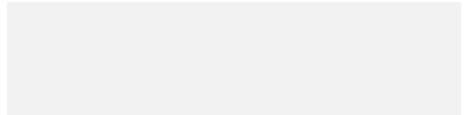
30th May 2024, 12:15h - 14:15h, 120 min

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# Lennon John

## Multiple Choice Questions













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Wait until the beginning of the exam before turning the page. This document is printed double-sided and has 20 multiple choice questions. Each question has exactly one correct answer. Do not remove the staple. The exam contains 12 pages.

Carefully read the following instructions:

- Place your student card on the table.
- Draft paper is available, so **please do not write on the exam**. Calculators and electronic devices are **not allowed**.
- The exam is corrected electronically. Use a **pen (not a pencil) with black or dark blue ink** and avoid altering and erasing your answers if possible. If you must change an answer, use correction tape (avoid correction fluid). Do not draw an empty box.
- The grading scheme for the multiple choice questions is:
  - +1.5 point for a correct answer,
  - 0 points if no answer is given,
  - −0.5 point for a wrong answer.
- If a question contains a mistake, the teacher can remove it from the exam.
- Follow these guidelines for **marking your answers**:

Respectez les consignes suivantes   Read these guidelines   Beachten Sie bitte die unten stehenden Richtlinien		
choisir une réponse   select an answer Antwort auswählen	ne PAS choisir une réponse   NOT select an answer NICHT Antwort auswählen	Corriger une réponse   Correct an answer Antwort korrigieren
  		 
ce qu'il ne faut <b>PAS</b> faire   what should <b>NOT</b> be done   was man <b>NICHT</b> tun sollte		
     		

# CORRECTION

**Question 1 :** Consider an office building with 4 floors. During the lunch time, staff move between floors to gather with other colleagues. The origin-destination table given below illustrates the movement patterns during lunch hour. Note that rows correspond to the origins and columns to the destinations.

Which of the following statements is *correct*?

	Ground Floor	Floor 1	Floor 2	Floor 3	Floor 4
Ground Floor	0	10	5	0	2
Floor 1	15	0	3	2	0
Floor 2	20	2	0	0	1
Floor 3	0	5	2	0	4
Floor 4	3	0	0	10	0

- ☒ The ground floor is predominantly a destination for people from all other floors.
- ☐ Most people on the second floor prefer to go to the fourth floor during lunch.
- ☐ The fourth floor sends and receives the most people during lunch hour.
- ☐ The third floor has an equal number of people arriving from and departing to all other floors.

**Question 2 :** You are an engineer and need to estimate the car traffic flows on a road in a certain city. Fortunately, you have the 4 tabular data below.

	Node ID	Latitude	Longitude	Point type
Data 1	0	46.57	6.51	Start of Road
	1	46.29	6.78	End of Road
	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮

	Road ID	Capacity	Maximum Speed
Data 2	0	4	40
	1	6	50
	⋮	⋮	⋮
	⋮	⋮	⋮

	Road ID	Start Node ID	End Node ID
Data 3	0	0	1
	1	1	2
	⋮	⋮	⋮
	⋮	⋮	⋮

	Latitude of Departure	Longitude of Departure	Latitude of Arrival	Longitude of Arrival	Number of Car Trip
Data 4	46.61	6.49	46.21	6.49	100
	46.10	6.37	45.70	6.37	200
	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮

Which tabular data is *NOT* required for estimating the car traffic flows?

- ☐ Data3.
- ☐ Data1.
- ☒ Data2.
- ☐ Data4.

# CORRECTION

**Question 3 :** The city council is considering implementing a toll increase on a major highway to reduce congestion during peak hours. The demand function is  $x = 4000 - 120t$ , where  $x$  is the number of vehicles per hour and  $t$  is the toll in CHF. The current traffic flow is 1000 vehicles per hour with the toll being 25 CHF. The council is debating a proposal to increase the toll to 26 CHF.

*Which of the following statements is **correct**?*

- ☐ Traffic flow increases to 1880 vehicles per hour and demand is elastic.
- ☐ Traffic flow decreases to 880 vehicles per hour and demand is inelastic.
- ☒ Traffic flow decreases to 880 vehicles per hour and demand is elastic.
- ☐ Traffic flow increases to 1880 vehicles per hour and demand is inelastic.

**Question 4 :** *Which of the following statements on system optimum (SO) is **correct**?*

- ☐ The objective function of the SO is the maximum travel time in the network.
- ☒ The objective function of the SO is the average or total travel time spent in the network.
- ☐ The system optimum may not exist in the presence of congestion.
- ☐ The objective function of the SO is the sum of the integrals of the link performance functions.

**Question 5 :** *Which of the following statements is **wrong**?*

- ☐ Subjectivity plays a role in selecting a project from the Pareto optimal set.
- ☐ Consumer surplus is the difference between willingness to pay and actual price.
- ☒ There is a unique way to transform non-monetary costs and benefits into monetary units.
- ☐  $i^* \in C$ , where  $C$  is a set of projects.  $i^*$  is Pareto optimal if no indicator can be improved without degrading at least one of the others.

**Question 6 :** At the end of a concert, there is a continuous flow of  $f = 50$  persons per minute that needs to be transported with shuttles to the nearby metro station. The operations need to be optimized during a time horizon  $t_H$ . The cost per shuttle trip is  $c = 200$  CHF, and the concertgoers are willing to pay  $W = 1$  CHF per minute to reduce their waiting time. The waiting time per trip is calculated as  $\frac{\delta^2 f}{2}$  and the number of trips as  $\frac{t_H}{\delta_t}$ . The decision involves determining the headway  $\delta_t$ , which minimizes the generalized cost combining the actual transportation cost and the perceived cost of waiting time as experienced by the travelers.

*What is the optimal headway  $\delta_t$  that minimizes the generalized cost of the shuttle service?*

- ☐ 1 minute.
- ☐ 4 minutes.
- ☒  $2\sqrt{2}$  minutes.
- ☐  $\sqrt{2}$  minutes.

# CORRECTION

**Question 7 :** A road maintenance company is asked to repair a stretch of road with an initial quality index  $g_0 = 80$  and a degradation rate  $\tau = 0.02$  per year. The company should decide between two maintenance strategies:

**Strategy A:** Perform repairs every 3 years.

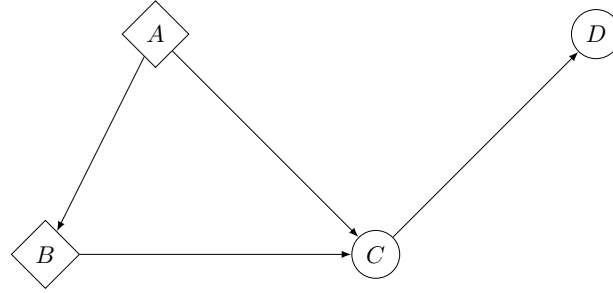
**Strategy B:** Perform repairs whenever the road quality index drops below  $g_{min}$ .

The repair costs follow the function  $c(t) = 1000 + 500t$ , where  $t$  is the time since the last repair expressed in years. The quality of road depends of its condition  $g$  that follows linear degradation law  $g(t) = g_0 - \tau \cdot t$ . We want to choose the strategy that results in lower cumulative costs over  $n$  years.

Which of the following statements is **correct**?

- ☐ Strategy B is better regardless of values for  $g_{min}$  and  $n$ .
- ☐ Strategy A is better regardless of values for  $g_{min}$  and  $n$ .
- ☐ Strategy A is better if  $g_{min} = 75$  and  $n = 20$ .
- ☒ Strategy B is better if  $g_{min} = 75$  and  $n = 20$ .

**Question 8 :** Consider the following network where each path starts and ends at a centroid ( $A, B, C$  or  $D$ ).



Based on this network, the corresponding link-path incidence matrix with a missing column, is as follows:

	1	2	3	4	5	6	7	8
(A, B)	1	0	0	0	1	0	0	?
(A, C)	0	1	0	1	0	0	0	?
(B, C)	0	0	0	0	1	1	1	?
(C, D)	0	0	1	1	1	0	1	?

Which path is missing in the given link-path incidence matrix?

- ☐  $A \rightarrow B \rightarrow C \rightarrow D$
- ☐  $B \rightarrow C$
- ☐  $A \rightarrow B$
- ☒  $A \rightarrow B \rightarrow C$

## CORRECTION

**Question 9 :** Consider a discrete choice model, modelling the choice between two alternatives using utility theory. Each alternative is associated with a utility specified as follows:

$$u_1 = \gamma_1 + \theta_x x_1 + \theta_y y_1$$

$$u_2 = \gamma_2 + \theta_x x_2 + \theta_y y_2$$

where  $\gamma_1$  and  $\gamma_2$  are alternative-specific constants for alternatives 1 and 2 respectively.  $\theta_x$  and  $\theta_y$  are generic coefficients for variables  $x$  and  $y$ , respectively.  $x_1$ ,  $x_2$ ,  $y_1$ , and  $y_2$  are value of variables  $x$  and  $y$  for the alternatives.

Which of the following statements is **wrong**?

- ☐ Alternative 1 is chosen if  $\gamma_1 \geq \gamma_2$ ,  $x_1 = x_2$  and  $y_1 = y_2$ .
- ☐ Alternative 1 is chosen if  $(\gamma_1 - \gamma_2) + \theta_x(x_1 - x_2) + \theta_y(y_1 - y_2) \geq 0$
- ☒ Alternative 1 is chosen if  $\frac{u_1}{u_2} \geq 1$ .
- ☐ Alternative 1 is chosen if  $u_1 \geq u_2$

**Question 10 :** What does the Braess Paradox demonstrate in traffic networks?

- ☐ Traffic signals have no effect on congestion.
- ☒ Removing a road from a traffic network can sometimes reduce congestion.
- ☐ Building larger cars will reduce traffic jams.
- ☐ Adding more roads to a traffic network always reduces overall congestion.

**Question 11 :** Which of the following statements on Referenced preferences (RP) and Stated preferences (SP) data is **wrong**?

- ☒ Demand for new travel modes can be readily predicted using only RP data.
- ☐ Analysts should be cautious about relying on the credibility of SP data, as people's actual behavior may not always correspond to their survey responses.
- ☐ SP data allow to observe several choices from the same individual.
- ☐ Analysts can control the variability of attributes, the alternatives presented, and the level of correlation in an SP survey.

**Question 12 :** Which of the following statements on congestion pricing is **wrong**?

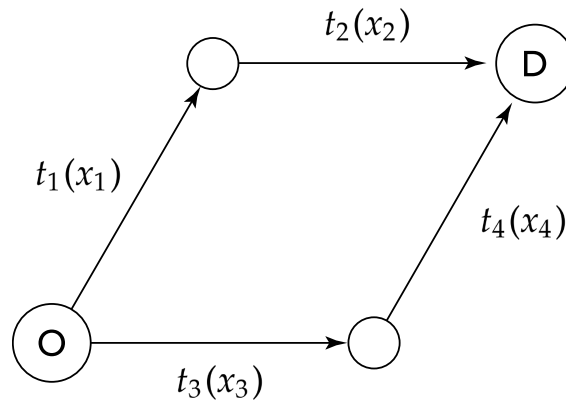
- ☐ Congestion pricing is a strategy used to adjust the generalized costs of the users so that the user equilibrium coincides with the system optimum.
- ☒ The congestion charge must be equal to the price of anarchy (in monetary units) to have an equivalence between user equilibrium and system optimum.
- ☐ Congestion pricing can improve the level of service of new or existing systems, by spreading out demand and reducing congestion at peak hours.
- ☐ In order to reach the system optimum, the congestion charge must depend on the traffic of each link.

CORRECTION

**Question 13 :** Which of the following statements about the first step of the 4-step model is **wrong**?

- ☐ The number of trips produced and attracted by a zone depends on demographic and economic characteristics of the zone, such as population, numbers of employment, etc.
- ☐ The number of trips produced and attracted by a zone depends on the accessibility of the zone and, therefore, the transportation network's performance.
- ☐ The number of trips produced and attracted by a zone depends on the size of the zone.
- ☒ The number of trips produced and attracted by a zone depends on the number of trips produced and generated by the contiguous zones

**Question 14 :** Consider the network below, where link performance functions  $t_\ell(x_\ell)$ ,  $\ell = 1, \dots, 4$  are:



$$t_1(x_1) = 100 + 0.05 \cdot x_1$$

$$t_2(x_2) = 0.15 \cdot x_2$$

$$t_3(x_3) = 50 + 0.05 \cdot x_3$$

$$t_4(x_4) = 0.25 \cdot x_4$$

Note that paths  $p_1$  and  $p_2$  consist of links as follow:

$$p_1 = \{1, 2\}$$

$$p_2 = \{3, 4\}$$

If OD flows are 500, What is the path cost  $(c_1, c_2)$  based on user equilibrium?

- ☐ (200, 300)
- ☐ (160, 110)
- ☒ (140, 140)
- ☐ (26400, 43800)

# CORRECTION

**Question 15 :** Which of the following statements on the value of time is *correct*?

- ☐ The value of time is universally constant across all demographic groups and does not vary with income levels.
- ☒ The value of time is a measure used in transportation engineering to quantify how much people are willing to pay to save time.
- ☐ The value of time is determined by government regulations to perform cost-benefit analysis.
- ☐ The value of time is a measure used in transportation engineering to quantify how much people are willing to reduce their travel speed.

**Question 16 :** A project manager is quantifying costs and benefits of two project to determine whether either project is favorable. The costs and benefits of the two projects are quantified and summarized in the table below. All reported numbers are net present values.

Project	Cost [Million CHF]	Benefit [Million CHF]
A	100	120
B	200	260

Which of the projects is preferred according to cost-benefit analysis?

- ☒ Project B.
- ☐ Both are equally favorable.
- ☐ Project A.
- ☐ None.

**Question 17 :** Which of the following statements on the likelihood for models is *correct*?

- ☒ The log likelihood function in a discrete choice model measures the probability of observing the given data under specific model parameters.
- ☐ The log likelihood increases as the sample size decreases, making smaller samples preferable for model estimation.
- ☐ The log likelihood for a discrete choice model is calculated by summing the raw probabilities of each choice being selected.
- ☐ The log likelihood is typically calculated using the squared differences between observed and predicted probabilities to adjust for any discrepancies.

**Question 18 :** Which of the following statements is *correct*?

- ☐ Dijkstra's algorithm is designed to handle the Wardrop's first principle (user equilibrium), where no user can reduce their travel time by unilaterally changing routes.
- ☒ Dijkstra's algorithm can be used as part of a broader iterative approach to approximate user equilibrium in a network.
- ☐ Dijkstra's algorithm can directly compute the user equilibrium travel times in a network where travel times are dependent on flow.
- ☐ Dijkstra's algorithm inherently optimizes for the total system travel time, thereby achieving system optimal conditions by distributing traffic evenly across all paths.

CORRECTION

**Question 19 :** A traveler  $n$  commuting to work has a choice between private motorized mode (pmm) and public transportation (pt). The analyst has established that the utility functions associated with each mode are as follows:

$$U_{pt,n} = -\theta_c \cdot \text{cost}_{pt,n} - \theta_t \cdot \frac{\text{time}_{pt,n}^\lambda}{\lambda},$$

$$U_{\text{pmm},n} = -\theta_c \cdot \text{cost}_{\text{pmm},n} - \theta_t \cdot \log(\text{time}_{\text{pmm},n})$$

where  $\text{cost}_{\text{pmm},n}$  and  $\text{cost}_{pt,n}$  are the cost of the trip by private motorized mode and public transportation respectively for individual  $n$  in CHF, and  $\text{time}_{\text{pmm},n}$  and  $\text{time}_{pt,n}$  are the corresponding travel times in minutes.

Using observations from existing travelers, the analyst has inferred the value of the parameters:  $\theta_c = 2$ ,  $\theta_t = 1$  and  $\lambda = 1.5$ .

*What is the value of time of traveler  $n$  for public transportation, expressed in CHF/minutes?*

- ☐ 0.5
- ☒ The numerical value cannot be determined with the given information since the value of time is expressed as a function of  $\text{time}_{pt,n}$ .
- ☐ The numerical value cannot be determined with the given information since the value of time is expressed as a function of  $\text{cost}_{pt,n}$ .
- ☐ 2

**Question 20 :** The local government has given subsidy on electric bikes in order to promote greener transport. Using the subsidy, the price of an electric bike changed from 600 CHF to 500 CHF. Consequently, sales of electric bikes has increased from 200 units to 250 units per month.

*Which of the following statements is **wrong**?*

- ☐ Despite the subsidy, the total cost to the government may still result in a net benefit to society if it leads to increased use of environmentally friendly transportation and reduces other societal costs such as pollution and traffic congestion.
- ☐ The subsidy increased total revenue from electric bicycle sales.
- ☐ The additional consumer surplus generated by this price change indicates that users are better off in terms of social welfare.
- ☒ The subsidy on electric bikes primarily benefits the manufacturers and has minimal impact on consumers since the price reduction is too small to significantly affect demand.



## CORRECTION

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