NATIONAL EXAMINATION MAY 2017

16-Civ-B7, Transportation Planning & Engineering

3 HOURS DURATION

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper a clear statement of any assumptions made.
2. Candidates may use one of two calculators, the Casio approved model or the Sharp approved model.
3. This is a closed book-examination. One two-sided aid sheet is permitted.
4. Any **five** questions constitute a complete examination and only the first five questions, as they appear in your answer book, will be marked.
5. All questions are of equal value (20 marks)

QUESTION 1:

(a) Explain how land use development affects transportation systems and how improved transportation facilities induces new land use development. Why is this important in travel demand forecasting?

(b) Multinomial logit models are commonly used to predict mode choices made by travelers in transport planning. This type of models assumes independence of irrelevant alternatives (IIA). Explain why the IIA property may yield unrealistic results of mode choice in some cases and how to overcome the limitation of the IIA property.

(c) Discuss how the advanced traveller information system (ATIS) helps control travel demand for a sustainable transportation system.

QUESTION 2:

Vehicles began arriving at a parking lot at 8:00 am at a rate of 12 vehicles/min. Due to an accident on the access road to the parking lot, no vehicles arrived from 8:30 to 8:45 am. From 8:45 am, vehicles arrived at 3 vehicles/min. The parking lot attendant collected parking fee and lets vehicles enter the parking lot at a rate of 6 vehicles/min.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from 8:00 am and determine the time when the queue cleared.

(b) Calculate the maximum queue length (maximum number of vehicles in the queue) and the maximum waiting time in the queue.

(c) Calculate 1) the total vehicle delay and 2) the average delay per vehicle from 8:00 am until the queue cleared.

QUESTION 3:

The following table shows the number of households and the number of trips produced from each household type (categorized by household size and income level).

	Household size (persons/household)					
	1		2		3+	
Income level	No. of HH	No. of Trips	No. of HH	No. of Trips	No. of HH	No. of Trips
Low	500	1220	450	1300	500	1950
Medium	600	1860	700	2950	800	3700
High	500	2125	800	4500	750	3600

The following table summarizes the forecasted household composition in a target year.

Forecasted number of households

	Household size (persons/household)		
Income level	1	2	3+
Low	35	69	47
Medium	50	83	29
High	71	23	16

(a) Calculate the forecasted number of trips for each household type (classified by household size and income level) for a target year.

(b) Alternatively, trip rate can be estimated using the following linear regression equation.

Trip rate = 0.99 + 0.91 * INCOME + 0.59 * SIZE

where
INCOME = household income (1 = Low, 2 = Medium, 3 = High);
SIZE = household size (if 3 or more, SIZE = 3).

Calculate the forecasted number of trips for each household type for a target year using this estimated trip rate.

(c) Compare underlying assumptions and limitations between the methods used in (a) and (b).

QUESTION 4:

Traffic on a single-lane highway (no passing is allowed) is travelling at 40 km/hour with a density of 25 vehicles/km. The capacity of the highway is 1,400 vehicles/hour and the free-flow speed is 50 km/hour. On one day, the road was blocked for 5 minutes due to a stopped vehicle. Assume that the vehicles started moving again immediately after the stopped vehicle was removed. Determine the followings using the Greenshields' model or the shock wave theory:

(a) The jam density and the density at capacity.

(b) The length of the platoon immediately after the stopped vehicle was removed.

(c) The speed of the front of the platoon after the stopped vehicle was removed.

(d) The time it would take for the platoon to dissipate after the stopped vehicle was removed. Assume that there was no congestion on the road further downstream of the stopped vehicle.

QUESTION 5:

Consider the trip distribution in zone 1 and zone 2. The total trip productions from zones 1 and 2 are 270 and 230, respectively. The total trip attractions to zones 1 and 2 are 320 and 180, respectively. The travel time between zone 1 and zone 2 (inter-zonal travel time) is 10. The travel time within the same zone (intra-zonal travel time) is 4.

(a) Estimate the numbers of intra-zonal and inter-zonal trips using the gravity model. The friction factor between zone i and zone j (F_{ij}) is defined as follows:

$$F_{ij} = \frac{1}{t_{ij}}$$ where t_{ij} = travel time between zone i and zone j;

(b) Re-estimate the numbers of intra-zonal and inter-zonal trips using the following friction factor:

$$F_{ij} = \frac{1}{t_{ij}^2}$$

(c) Compare the results in parts (a) and (b). Explain the effects of friction factor on trip distribution based on the results.

QUESTION 6:

Trip makers can choose one of the following four modes of travel – automobile, bus, rail and bike. The utility functions for each mode are as follows:

$$V_i = -0.075 * AT_i - 0.05 * WT_i - 0.04 * RT_i - 0.002 * TC_i$$

where

V_i = observable utilities for mode i;
AT_i = access time for mode i (minutes) (e.g., walk time to the bus stop, rail station or destination);
WT_i = waiting time for mode i (minutes);
RT_i = riding time for mode i (minutes);
TC_i = out-of-pocket travel cost for mode i (cents).

The values of each mode attribute are shown below.

Mode	Access time (minutes)	Waiting time (minutes)	Riding time (minutes)	Out-of-pocket cost (cents)
Auto	6	1	25	300
Bus	10	15	40	60
Rail	7	10	30	75
Bike	1	0	60	0

(a) Calculate the share of each mode using the multinomial logit model.

(b) The city will construct bike paths to encourage people to use bikes. The city expects that the paths will reduce riding time by bike to 45 min. Assume that the values of all other mode attributes remain the same as above. What will be the new share of each mode?

(c) Describe the effects of access time, waiting time, riding time and out-of-pocket cost on modal splits. Explain whether the effects are realistic or not and why.

QUESTION 7:

Consider a low-capacity single town-centre route and a high-capacity bypass. The travel times for the two routes are estimated as follows:

$$t_b = 12 + 0.004V_b,\ t_t = 8 + 0.016V_t$$

where t_b and t_t are travel times on the bypass and the single town-centre route, respectively, and V_b and V_t are the corresponding volumes. A total volume of using the two routes is 2,500.

(a) Determine the traffic volume and travel time on the two routes at the user-equilibrium (UE) condition.

(b) To relieve the congestion on the existing two routes, a new bypass will be built. The travel time for this additional bypass is estimated as follows:

$$t_{b'} = 16 + 0.002V_{b'}$$

where $t_{b'}$ and $V_{b'}$ are the travel time and volume on the new bypass, respectively. Determine the new traffic volumes and travel time on the three routes at the UE condition.

(c) In the above problems, we implicitly assume that the drivers always know the travel time in each route. Explain the limitation of this assumption and how to overcome this limitation in modeling route choice.

Marking scheme:

Question	Sub-questions	Marks
1	(a)	6
	(b)	7
	(c)	7
2	(a)	10
	(b)	5
	(c)	5
3	(a)	8
	(b)	8
	(c)	4
4	(a)	4
	(b)	10
	(c)	2
	(d)	4
5	(a)	8
	(b)	8
	(c)	4
6	(a)	7
	(b)	7
	(c)	6
7	(a)	6
	(b)	10
	(c)	4