NATIONAL EXAMINATION

DECEMBER 2018

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. Candidates are allowed to bring **ONE** aid sheet 8.5" X 11" hand-written on both sides containing notes and formulae.
4. Any **five** of seven 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 the trip makers' socioeconomic characteristics associated with trip frequency. Provide examples.

(b) Give an example of how the travel demand management strategy will change travel demand. Discuss potential impacts of the change in travel demand on society.

(c) Determine whether the following factors will increase or decrease the capacity of highways. Explain the reason.

- Higher percentage of trucks and buses;
- More number of lanes;
- Steeper downgrade.

QUESTION 2:

Consider traffic flow in an one-lane road. The arrival rate is 1500 vehicles/hour from 9:00 am to 11:00 am and drops to 750 vehicles/hour thereafter. The capacity of the lane is 1250 vehicles/hour.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from 9:00 am to the time when the queue clears.

(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.

QUESTION 3:

The number of household trips is predicted using the data from the household survey for three zones 1, 2 and 3 as follows:

Zone	No. of households	No. of residents per household	No. of workers per household
1	10,000	2.0	1.0
2	20,000	3.0	2.0
3	40,000	3.0	1.0

(a) Assume that a household trip generation model was estimated using a linear regression model as follows:

Trip rate = 0.2 + 0.5 * NRES + 1.1 * NWOR

where
Trip rate = no. of trips per household;
NRES = no. of residents per household;
NWOR = no. of workers per household.

Calculate the number of trips for each zone using the above trip rates. Discuss the effects of numbers of residents and workers on the trip rate based on the above model.

(b) Suppose households were classified by the number of residents per household (2 or less and 3 or more) and the number of workers per household (1 or less and 2 or more). The trip rates were estimated using the cross-classification method as follows:

Trip rate (no. of trips per household)

	No. of workers per household	
No. of residents per household	1 or less	2 or more
2 or less	2.1	2.5
3 or more	3.2	4.1

Calculate the number of trips for each zone using the above trip rates.

(c) What is the fundamental difference in assumptions between the two methods used in (a) and (b)? Discuss one advantage and one disadvantage of each method.

QUESTION 4:

Vehicles are normally travelling at the speed of 80 km/h on a single-lane highway with the free-flow speed of 100 km/hour and the capacity of 2500 vehicles/hour. On one day, a tractor with the speed of 15 km/hour entered the highway, traveled 1.0 km at the same speed and exited the highway. Consequently, the vehicles immediately behind the tractor had to lower the speed to 15 km/h behind the tractor and formed a platoon with the density of 85 vehicles/km and the flow of 1275 vehicles/hour. Determine the followings using the Greenshields' model or the shock wave theory:

(a) The jam density and the density at capacity of the vehicle flow.

(b) The length of the platoon immediately after the tractor exited.

(c) The speed of the front of the platoon after the tractor exited.

(d) The time it took for the platoon to dissipate after the tractor exited. Assume that there was no congestion on the road further downstream of the point where the tractor exited.

QUESTION 5:

Consider three zones – zones 1, 2 and 3. The total trip productions from zones 1, 2 and 3 are 100, 160 and 140, respectively. The total trip attractions to zones 1, 2 and 3 are 130, 70 and 200, respectively. The travel times within the same zone (intra-zonal) and between different zones (inter-zonal) are shown below.

Travel time

From \ To	1	2	3
1	2	5	3
2	5	2	4
3	3	4	2

(a) Estimate the number 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:

$$F_{ij} = \frac{1}{t_{ij}^2} \qquad \text{where } t_{ij} = \text{travel time between zone } i \text{ and zone } j;$$

(b) Provide an example of the potential factor affecting trip distribution, which is not a quantitative measure. Discuss how this factor can be considered in the gravity model.

QUESTION 6:

Consider two traffic zones – zone A is a residential area and zone B is a commercial area. The commercial area in zone B mainly includes job places for the workers who live in the residential area in zone A. There are currently two routes from zone A to zone B (called "route 1" and "route 2"). Each route has the following travel time function:

$$t_1 = 1.5 + \frac{3V_1}{200},\ t_2 = 4.25 + \frac{V_2}{80}$$

where t_1 and t_2 = travel times on routes 1 and 2, respectively (minutes), and V_1 and V_2 = volumes on routes 1 and 2, respectively (vehicles/hour). A total volume from zone A to zone B is 4,400 vehicles/hour.

(a) Compute the traffic volume and travel time on each of the two routes in the User Equilibrium (UE) condition.

(b) To relieve the congestion on the existing two routes, the city government considers building a new route (called "route 3"). Route 3 has the following travel time function:

$$t_3 = 0.4 + \frac{V_3}{125}$$

where t_3 = travel time on route 3 (minutes) and V_3 = volumes on route 3 (vehicles/hour).

Compute the new traffic volume and travel time on each of the three routes in the UE condition.

(c) In this question, it was assumed that drivers always take the shortest path. Discuss the limitation of this assumption and how you would overcome the limitation in this route choice problem.

QUESTION 7:

Trip makers in a city 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 a bike path to encourage people to use bikes. The city expects that the bike path will reduce riding time by bike to 45 min. Assume that the values of all other mode attributes remain the same as above. Calculate the new share of each mode.

(c) The multinomial logit model may predict unrealistic mode share due to the assumption of the independent of irrelevant alternatives (IIA) property. Explain the IIA property and how you would account for the limitation of the IIA property in predicting mode choice using the multinomial logit model.