NATIONAL EXAMINATION DECEMBER 2015

98-Civ-A6, 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 the interaction between residential land development and transit use.

(b) Explain the differences among home-based work trips, non-home-based work trips and non-home-based other trips. Also explain why trips are forecasted separately for these three types?

(c) Describe the advantage(s) and disadvantage(s) of using a household-based trip generation model rather than a zone-based trip generation model.

QUESTION 2:

Vehicles arrive a freeway section at the rate of 100 vehicles/min from 8:00 am to 8:10 am. Then their arrival rate decreases to 80 vehicles/min from 8:10 am to 8:25 am and further decreases to 25 vehicles/min thereafter. The capacity of the freeway is 60 vehicles/min.

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

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

(c) Calculate 1) the total vehicle delay and 2) the average delay per vehicle.

QUESTION 3:

The following table shows the forecasted number of households and trip rates for different household types classified by the number of vehicles per household and the household income in a given traffic zone.

	Household income					
	Low		Medium		High	
Vehicles/HH	No. of HH	Trip rate (trips/HH)	No. of HH	Trip rate (trips/HH)	No. of HH	Trip rate (trips/HH)
0	11	2	11	3	0	7
1	37	7	240	8	10	13
2	7	12	120	13	41	18
3 or more	0	17	4	18	19	23

(a) Calculate the forecasted number of trips for each household type.

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

Trip rate = 1.225 + 5.1 * AUTO + 2.875 * INC

where
AUTO = no. of vehicles per household (if 3 or more, AUTO = 3);
INC = household income (INC = 0 for Low, INC = 1 for Medium, and INC = 2 for High).

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

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

QUESTION 4:

Consider a single-lane highway with the free-flow speed of 60 km/h and the jam density of 144 vehicles/km. In normal traffic condition, vehicles are travelling at the speed of 45 km/h. On one day, a truck with the speed of 10 km/h entered the highway, traveled 1.0 km at the same speed and exited the highway. Consequently, the vehicles immediately behind the truck had to lower the speed to 10 km/h behind the truck and formed a platoon with the density of 120 vehicles/km and the flow of 1200 vehicles/h. Apply the Greenshields' model or the shock wave theory to determine:

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

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

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

QUESTION 5:

The total trip productions from zones 1 and 2 are 450 and 550, respectively. The total trip attractions to zones 1 and 2 are 700 and 300, respectively. The travel distance between zone 1 and zone 2 is 10 km. The travel distance within the same zone is 5 km.

(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:

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

(b) Assume that the total trip productions from zones 1 and 2 will increase to 600 and 800, respectively, in a target year. The total trip attractions to zones 1 and 2 will also increase 950 and 450, respectively. The intra-zonal and inter-zonal travel distances remain the same. Estimate the forecasted number of intra-zonal and inter-zonal trips in the target year using the gravity model.

(c) List the potential factors affecting trip distribution other than travel distance.

QUESTION 6:

A residential area is linked to a commercial area by two highways - Highway 1 and Highway 2. The travel time functions for these two highways are described as follows:

$$t = 10 + 20\left(\frac{V}{C}\right)$$

where t = travel time on the highway (minutes), V = volume on the highway (vehicles/hour), and C = capacity of the highway (vehicles/hour). The capacities of Highways 1 and 2 are 2,200 vehicles/hour and 3,000 vehicles/hour, respectively. Total volume from the residential area to the commercial area is 8,000 vehicles/hour.

(a) Compute the traffic volume and travel time on the two highways at the User Equilibrium (UE) condition.

(b) To alleviate the congestion on the two existing highways, a new highway (Highway 3) with the capacity of 2,800 vehicles/hour is added. The travel time function of the highway is the same as the functions for Highways 1 and 2. Compute the new traffic volumes and travel times on the three highways at the UE condition. Will the travel time in each highway be reduced?

(c) Why does the addition of a new highway sometimes increase travel times on all highways at a UE condition?

QUESTION 7:

Commuters choose auto or bus for their trips. The utility function for each travel mode was calibrated as follows:

$$V = C - 0.10 * X_1 - 0.13 * X_2 - 0.12 * X_3 - 0.0045 * X_4$$

where

V = observable utilities;
C = constant;
X_1 = waiting time (min);
X_2 = travel time (min);
X_3 = parking time (min);
X_4 = out-of-pocket cost (cents).

The values of the parameters in the above utility function for each mode are shown below.

Mode	C	X_1 (min)	X_2 (min)	X_3 (min)	X_4 (cents)
Auto	-0.33	0	20	5	225
Bus	-0.27	10	35	0	100

(a) Calculate the mode splits of auto and bus using the multinomial logit model.

(b) In the part (a), the new light rail will be added as the third mode of travel. The utility function for light rail is the same as above and the values of the parameters for light rail are shown below.

Mode	C	X_1 (min)	X_2 (min)	X_3 (min)	X_4 (cents)
Light rail	0	15	25	0	150

Predict the mode splits of auto, bus and light rail using the multinomial logit model.

(c) Does the result in (b) make intuitive sense? Comment on the result based on the independent of irrelevant alternatives (IIA) property of the multinomial logit model and suggest how to overcome the limitations of the IIA property in this mode choice problem.

Marking scheme:

Question	Sub-questions	Marks
1	(a)	7
	(b)	7
	(c)	6
2	(a)	10
	(b)	5
	(c)	5
3	(a)	6
	(b)	10
	(c)	4
4	(a)	4
	(b)	12
	(c)	4
5	(a)	8
	(b)	8
	(c)	4
6	(a)	6
	(b)	10
	(c)	4
7	(a)	5
	(b)	7
	(c)	8