National Examination May 2016

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 how residential development in low-density suburban areas affects mode choice and travel distance of work trips.

(b) Describe potential travel demand management strategies which can increase average vehicle occupancy during commuter peak hours. Explain how these strategies would change travel patterns, travel time and fuel consumption.

(c) Describe the factors affecting trip production and trip attraction in a zonal level. Explain their effects on trip generation and why.

QUESTION 2:

Vehicles arrive in a single approach for two consecutive cycles at a signalized intersection. The signal has a 80 sec. cycle time with a 40 sec. green interval and a 40 sec. red interval (ignore yellow interval). The arrival rates are assumed to be constant in both cycles. The arrival rate was 1,170 vehicles/hour in the first cycle and it decreased to 630 vehicles/hour in the second cycle. Assume that the vehicles in the queue formed on red pass through the intersection during the subsequent green interval at the saturation flow rate of 1,800 vehicles/hour immediately after the start of the green interval.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) for the approach during the two cycles.

(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 during the two cycles.

QUESTION 3:

The following table shows the numbers of households and trips for different household types classified by the number of persons per household and the number of vehicles per household in a given traffic zone.

	Vehicles/household					
	0		1		2 or more	
Persons/household	No. of households	No. of trips	No. of households	No. of trips	No. of households	No. of trips
1	100	220	150	620	100	360
2	70	340	140	860	30	210
3	60	420	130	1030	50	380
4	120	1010	110	1190	40	470
5 or more	10	110	40	460	35	420

The forecasted number of households in the study area for a target year is shown below.

	Vehicles/household		
Persons/household	0	1	2 or more
1	14	22	0
2	12	16	4
3	10	12	5
4	7	9	7
5 or more	6	8	10

(a) Calculate the forecasted number of trips for each household type (classified by the number of persons per household and the number of vehicles per household).

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

Trip rate = 0.67 + 2.07 * NPERSON + 0.85 * NVEH

where
NPERSON = no. of persons per household (if 5 or more, NPERSON = 5);
NVEH = no. of vehicles per household (if 2 or more, NVEH = 2)

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 the traffic flow on a one-lane road leading to a railway grade crossing. The capacity and jam density of the traffic flow are 2,000 vehicles/hour and 160 vehicles/km, respectively. Traffic flow in normal traffic condition is characterized by a volume of 1,500 vehicles/hour and a density of 40 vehicles/km. On one day, the gate was closed to allow a train to pass through the crossing and the vehicles stopped behind the gate while the train was passing. Three (3) minutes later, the gate was opened and the vehicles immediately started crossing. Determine the followings using the Greenshields' model or the shock wave theory:

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

(b) The length of the platoon immediately after the gate was opened.

(c) The time it would take for the platoon to dissipate after the gate was opened. Assume that there was no congestion on the road further downstream of the railway grade crossing.

QUESTION 5:

Consider two zones – zone 1 and zone 2. The total trip productions from both zones 1 and 2 are 250. The total trip attractions to zones 1 and 2 are 200 and 300, respectively. The travel time between zone 1 and zone 2 is 15. The travel time within the same zone is 5.

(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:

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

(b) Assume that the total trip productions from both zones 1 and 2 will increase to 350 in a target year. The total trip attractions to zones 1 and 2 will also increase to 300 and 400, respectively. The intra-zonal and inter-zonal travel times 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 time.

QUESTION 6:

Consider the commuter work trips from residential areas to a central business district (CBD) during the morning peak period. Two major routes, Routes 1 and 2, connect residential areas to CBD. These two routes do not overlap each other. Assume that the link performance functions for these two routes are as follows:

$$t_1 = 15 + \frac{V_1}{200},\ t_2 = 5 + \frac{V_2}{150}$$

where t_i = travel times on Route i (minutes), and V_i = volume on Route i (vehicles/hour). Assume that the total peak hour volume from residential areas to CBD is 1,800 vehicles/hour.

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

(b) Assume that a new route, Route 3, is added. The route does not overlap with Routes 1 and 2. The link performance function of Route 3 is as follows:

$$t_3 = 10 + \frac{V_3}{75}$$

where t_3 = travel time on Route 3 (minutes) and V_3 = volume on Route 3 (vehicles/hour). Compute the new traffic volumes and travel time on the three routes at UE conditions. Will the travel time in each route be reduced?

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

QUESTION 7:

Workers choose one of the following three travel modes for their trips: automobile, bus and light rail. Assume that the utility functions for travel by each mode are as follows:

$$V_a = 0.1 - 0.02 * IVTT_a - 0.15 * OVTT_a - 0.03 * TC_a$$
$$V_b = 0.2 - 0.03 * IVTT_b - 0.15 * OVTT_b - 0.03 * TC_b$$
$$V_r = \quad - 0.03 * IVTT_r - 0.15 * OVTT_r - 0.03 * TC_r$$

where

V_i = observable utilities for mode i (a = auto, b = bus, r = light rail);
$IVTT_i$ = in-vehicle travel time for mode i (minutes);
$OVTT_i$ = out-of-vehicle travel time for mode i (minutes);
TC_i = travel cost for mode i (dollars).

The travel time and cost for each mode are shown below.

Mode	In-vehicle travel time (minutes)	Out-of-vehicle travel time (minutes)	Travel cost (dollars)
Automobile	10	5	3.5
Bus	20	10	1.5
Light rail	12	15	2.0

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

(b) In the part (a), the bus company increases the numbers of service routes and bus stations, and frequency of services to reduce passengers' waiting time and walk time. It is expected that in-vehicle travel time and out-of-vehicle travel time by bus will be reduced to 15 and 8 minutes, respectively. Assume that the travel costs for all modes are unchanged. Predict the probability of choosing each mode 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) (b) (c)	7 7 6
2	(a) (b) (c)	10 5 5
3	(a) (b) (c)	8 8 4
4	(a) (b) (c)	4 12 4
5	(a) (b) (c)	8 8 4
6	(a) (b) (c)	6 10 4
7	(a) (b) (c)	6 6 8