NATIONAL EXAMINATION DECEMBER 2013

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

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

QUESTION 2:

Vehicles arrive in a single approach for two consecutive cycles at a signalized intersection. The signal has a 60 sec. cycle time with a 30 sec. green interval and a 30 sec. red interval (ignore yellow interval). The arrival rates are assumed to be constant in both cycles. The arrival rate was 1,080 veh/hour in the first cycle and it decreased to 720 veh/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 veh/hour immediately after the start of the green interval.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) 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 is the number of trips and the number of households 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	95	220	151	618	98	360
2	74	339	140	855	27	205
3	61	415	127	1027	35	381
4	122	1008	111	1188	42	471
5 or more	11	105	36	459	35	423

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	120	280	130
2	100	220	40
3	90	190	50
4	150	180	70
5 or more	30	60	60

(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 = 0.47 + 2.02 * NPERSON + 1.39 * 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 1,500 vehicles/hour and 100 vehicles/km, respectively. Traffic flow in normal traffic condition is characterized by a volume of 1,260 vehicles/hour and a density of 30 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. Six minutes later, the gate was opened and the vehicles immediately started crossing. Apply the Greenshields' model or the shock wave theory to determine:

(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 is no congestion on the road further downstream of the railway grade crossing.

QUESTION 5:

Consider trip distribution within 5 zones in an area. The total trip production from zone 1 is 1000. The travel times from zone 1 to zones 2, 3, 4 and 5 are 5, 10, 20, and 30 minutes, respectively. The trip attraction to zones 2, 3, 4 and 5 are 50, 200, 75, and 450, respectively. Assume that the number of trips produced from zone 1 to zones 2, 3, 4 and 5 is inversely proportional to the inter-zonal travel time.

(a) Estimate the number of trips from zone 1 to zones 2, 3, 4 and 5 using the gravity model.

(b) Assume that the future trip production from zone 1 will increase to 1,250 and the future trip attraction to zones 2, 3, 4 and 5 will increase to 100, 225, 100, and 600, respectively. Predict the number of trips from zone 1 to zones 2, 3, 4 and 5. The inter-zonal travel times remain the same.

(c) Compare the number of trips from zone 1 to each destination zone between (a) and (b). Identify the destination zone with the highest increase in the number of trips and explain why.

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:

$$t_1 = 11 + \left(\frac{V_1}{225}\right),\ t_2 = 6 + \left(\frac{V_2}{200}\right)$$

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:

$$t_3 = 7 + 2\left(\frac{V_3}{225}\right)$$

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:

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

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	12	7	2.5
Bus	20	12	0.75
Light rail	18	10	1.2

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

(b) In the part (a), the bus company increases the number of service routes and frequency of services to reduce passengers' waiting time. It is expected that in-vehicle travel time and out-of-vehicle travel time by bus will be reduced to 15 and 10 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)	6 7 7
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