NATIONAL EXAMINATION DECEMBER 2014

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 difference between a supply-side solution and a demand-side solution for transportation problems. Provide one example for each.

(b) Describe the assumptions of the gravity model for prediction of trip distribution. Discuss the limitations of the model.

(c) Provide the examples of criteria for evaluating different highway construction alternatives. Describe the method of evaluating the alternatives based on these criteria to choose the best alternative.

QUESTION 2:

Vehicles begin arriving at a parking lot at 7:00 am at a rate of 8 vehicles/min. Due to an accident on the access road to the parking lot, no vehicles arrive from 7:20 to 7:30 am. From 7:30 am, vehicles arrive at 2 vehicles/min. The parking lot attendant collects parking fee and lets vehicles in the parking lot at a rate of 4 veh/min.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from 7:00 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 caused by the accident.

QUESTION 3:

Trip generation in a residential zone is predicted based on the size and income of sample households as follows:

Trip rate (Number of trips per household)

	Household income		
Household size	Low	Medium	High
1	0.11	0.95	1.20
2	0.60	1.38	2.16
3	0.93	1.46	2.44
4 or more	1.03	1.69	2.60

Forecasted number of households in a target year

	Household income		
Household size	Low	Medium	High
1	42	27	32
2	170	220	132
3	83	104	93
4 or more	50	154	117

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

(b) Alternatively, the above travel survey data were used to calibrate the following linear regression equation for the expected trip generation rate by a household:

Trip rate = -0.16 + 0.33 * HSIZE + 0.72 * INC

where
HSIZE = household size (4 or more = 4);
INC = household income (Low = 0, Medium = 1, High = 2).

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

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

QUESTION 4:

Consider traffic flow on a single-lane, one-way road with a free-flow speed of 50 km/hour and a capacity of 1,500 veh/hour. On one day, vehicles are flowing at a speed of 40 km/hour. Suddenly, a large debris falls on the road and blocks the entire lane. Consequently, all the vehicles stop behind the debris. When the debris is removed 6 minutes after it falls, the vehicles immediately start moving again. Determine the followings using the Greenshields' model or the shock wave theory:

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

(b) The maximum length of the platoon.

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

QUESTION 5:

Trip distribution is predicted for an area within 5 zones. The total trip production from zone 1 is 1500. The travel times from zone 1 to zones 2, 3, 4 and 5 are 25, 50, 75, and 100 minutes, respectively. The trip attraction to zones 2, 3, 4 and 5 are 75, 300, 115, and 675, 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) Due to an increase in population, the future trip production from zone 1 will increase to 1875 and the future trip attraction to zones 2, 3, 4 and 5 will increase to 150, 340, 150, and 900, respectively. What will be the number of trips from zone 1 to zones 2, 3, 4 and 5? Assume that 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 two major routes for work-to-home trips from the commercial zone to the residential zone during the afternoon peak period. The travel time functions for the two routes are as follows:

$$t_1 = 10 + \frac{V_1}{200}, \quad t_2 = 20 + \frac{V_2}{100}$$

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). The total commuter afternoon peak hour volume from the commercial zone to the residential zone is 3,200 vehicles/hour.

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

(b) To reduce the travel time on Routes 1 and 2, the new route - Route 3 - has been suggested. Route 3 does not overlap with the two existing routes. This new route has the following travel time function:

$$t_3 = 15 + \frac{V_3}{150}$$

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.

(c) Would the addition of a new route always reduce travel time at UE conditions? If not, explain why.

QUESTION 7:

Commuters can choose automobile, bus and light rail as a travel mode for their work trips. Assume that the utility functions for each travel mode are as follows:

$$V_a = 0.3 - 0.04 * IVTT_a - 0.2 * OVTT_a - 0.06 * TC_a$$
$$V_b = 0.5 - 0.06 * IVTT_b - 0.2 * OVTT_b - 0.06 * TC_b$$
$$V_r = \quad - 0.06 * IVTT_r - 0.2 * OVTT_r - 0.06 * TC_r$$

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	Out-of-vehicle travel time	Travel cost
Automobile	12 min.	7 min.	$4.00
Bus	20 min.	12 min.	$2.50
Light rail	18 min.	10 min.	$3.00

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

(b) In the part (a), the bus company improved the operational service to reduce passengers' waiting time. Thus, in-vehicle travel time and out-of-vehicle travel time by bus are now reduced to 15 and 8 minutes, respectively. Assume that the travel costs for all modes are the same in the part (a). Predict the probability of choosing each mode.

(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)	8 6 6
2	(a) (b) (c)	10 4 6
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