NATIONAL EXAMINATION DECEMBER 2011

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 industry sector, household sector and local service sector are interrelated and how spatial distributions of these sectors will affect land use and transportation.

(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:

A construction is planned on a four-lane (one direction) highway. The duration of the construction is one hour and it requires the following two-step lane closure: three lanes are closed for the first 30 minutes and then two lanes are closed (i.e. one of the three closed lane is open) for the following 30 minutes. Assume that all lanes are open immediately after the construction. The arrival rate of vehicles is 4800 veh/hour and the capacity of the highway is 1800 veh/hour/lane.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from the beginning of the construction and determine the time when the queue cleared.

(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 caused by the construction.

QUESTION 3:

A travel survey was conducted to estimate trip generation in one study area. A sample of 20 households was interviewed and the survey data are summarized in the following table:

Number of sample households

	Automobile ownership					
	0		1		2 or more	
Household size	No. of households	No. of trips	No. of households	No. of trips	No. of households	No. of trips
1	2	11	1	5	0	0
2	1	4	3	18	1	9
3	1	5	2	15	2	21
4	0	0	1	8	2	23
5 or more	0	0	1	8	3	39

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

Forecasted number of households

	Automobile ownership		
Household size	0	1	2 or more
1	200	170	30
2	150	290	90
3	140	210	190
4	20	100	220
5 or more	10	80	310

(a) Calculate the forecasted number of trips for each household type (classified by household size and automobile ownership) for a target year.

(b) Alternatively, the expected trip generation rate by a household can also be estimated using the following linear regression equation:

Trip rate = 2.71 + 0.77 * HSIZE + 2.58 * AUTO

where
HSIZE = household size and AUTO = automobile ownership.

Calculate the forecasted number of trips for each household type 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:

Vehicles are traveling with speed of 60 kilometres/hour and a density of 40 vehicles/km on an one-lane road. The free-flow speed and capacity of this road are 75 km/hour and 2000 vehicles/hour, respectively. On one day, one vehicle suddenly lost power and became stalled on the road for 4 minutes. Thus, all the following vehicles had to stop behind the stalled vehicle. Immediately after the stalled vehicle regained power, the vehicle started 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 length of the platoon immediately after the vehicle started moving again.

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

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 25, 50, 100, and 150 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) Due to population and economic growth, the future trip production from zone 1 will increase to 1250 and the future trip attraction to zones 2, 3, 4 and 5 will increase to 100, 225, 100, and 600, 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 the commuter work trips from the residential zone to the commercial zone during the morning peak period. There are two major routes – Route 1 and Route 2. The travel time functions for the two routes are as follows:

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

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 peak hour volume from the residential zone to the commercial zone is 3,600 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:

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

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.

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

QUESTION 7:

Consider three travel modes for work trips – automobile, bus and light rail. The calibrated utility functions for travel by each mode are as follows:

$$V_a = 0.15 - 0.02 * IVTT_a - 0.1 * OVTT_a - 0.03 * TC_a$$
$$V_b = 0.25 - 0.03 * IVTT_b - 0.1 * OVTT_b - 0.03 * TC_b$$
$$V_r = \quad - 0.03 * IVTT_r - 0.1 * OVTT_r - 0.03 * TC_r$$

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 improved the operational service through realigning routes and running more buses 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 unchanged. 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 and suggest how to overcome the limitations of the IIA property in this mode choice problem.

Marking scheme:

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