NATIONAL EXAMINATION MAY 2012

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 land use and transportation influence each other and why this interaction is important for travel demand forecasting.

(b) Discuss the advantages and disadvantages of cross-classification analysis as compared to linear regression in predicting trip generation.

(c) Explain the difference in trip length and temporal distribution between work trips and non-work trips.

QUESTION 2:

Consider a freeway in one direction with a capacity of 3900 vehicles/hour and a constant vehicle arrival rate of 3000 vehicles/hour. An incident occurs on this freeway and it closes the freeway to all traffic for 12 minutes. Then, the freeway is partially opened with a flow of 2100 vehicles/hour for 19 minutes and restored to full capacity of 3900 vehicles/hour when the incident clears (i.e. 31 minutes after the incident occurs). Consequently, a queue forms and dissipates due to the incident.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from the time when the incident occurs to the time when the queue clears.

(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:

The following tables show household trip rates and the forecasted household composition in an urbanized area:

Trip rates (trips/household)

	Income		
Vehicles/household	Low	Medium	High
0	2	3	7
1	7	8	13
2	12	13	18
3 or more	17	18	23

Forecasted number of households

	Income		
Vehicles/household	Low	Medium	High
0	11	11	0
1	37	240	10
2	7	120	41
3 or more	0	4	19

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

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

Trip rate = – 1.65 + 5.1 * AUTO + 2.875 * INCOME

where
AUTO = number of vehicles per household (if 3 or more, AUTO = 3).
INCOME = household income (Low = 1, Medium = 2, High = 3);

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

(c) Explain the effects of the number of vehicles per household and household income on the trip rate based on the linear regression equation in (b). Does this make intuitive sense?

(d) Compare the methods used in (a) and (b) in terms of underlying assumptions and data requirements.

QUESTION 4:

Traffic flow on a one-lane highway in normal conditions is characterized by a speed of 50 km/hour and a density of 24 vehicles/km. The highway has a free-flow speed of 60 km/hour and a jam density of 144 vehicles/km. On one day, a truck enters the highway, travels for 6 minutes and exits the highway at a constant speed of 20 km/hour. Consequently, all vehicles follow the truck at the same speed of 20 km/hour. Apply the Greenshields' model and the shock wave theory to determine:

(a) The capacity of the highway and the density at capacity.

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

(c) The time it would take for the platoon to dissipate after the truck exits. Assume that there is no congestion on the highway further downstream of the exit point.

QUESTION 5:

Consider trip distribution within 5 zones in an area. The total trip attraction to zone 1 is 1050. The travel times from zones 2, 3, 4 and 5 to zone 1 are 25, 50, 75, and 100 minutes, respectively. The trip production from zones 2, 3, 4 and 5 are 100, 250, 300, and 400, respectively. Assume that the number of trips produced from zones 2, 3, 4 and 5 to zone 1 is inversely proportional to the inter-zonal travel time.

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

(b) Due to development of commercial areas in zone 1 and population growth in zones 2, 3, 4 and 5, the future trip attraction to zone 1 will increase to 1275 and the future trip production from zones 2, 3, 4 and 5 will increase to 175, 325, 350, and 425, respectively. What will be the number of trips from zones 2, 3, 4 and 5 to zone 1? Assume that the inter-zonal travel times remain the same.

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

QUESTION 6:

Consider the trips from an origin zone to a destination zone. There are two major routes – Route 1 and Route 2. The travel time functions for the two routes are as follows:

$$t_1 = 3 + 3\left(\frac{q_1}{100}\right),\ t_2 = 8.5 + \frac{q_2}{40}$$

where t_1 and t_2 = travel times on Routes 1 and 2, respectively (minutes), and q_1 and q_2 = volumes on Routes 1 and 2, respectively (vehicles/hour). The total number of trips is 4400 vehicles/hour.

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

(b) To relieve the congestion on Routes 1 and 2, the new route, Route 3 is proposed. This new route does not overlap with the two existing routes. Route 3 has the following travel time function:

$$t_3 = 0.8 + 2\left(\frac{q_3}{125}\right)$$

where t_3 = travel time on Route 3 (minutes) and q_3 = volume on Route 3 (vehicles/hour). Compute the new traffic volumes and travel times on the three routes at a UE condition.

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

QUESTION 7:

Commuters can choose one of the three modes of travel – automobile, bus and light rail – for their work trips. Based on the observed mode choices by a sample of commuters, the following utility functions were calibrated for each mode:

$$V_a = -0.33 - 0.13 * TT_a - 0.12 * PT - 0.45 * TC_a$$
$$V_b = -0.27 - 0.13 * TT_b - 0.1 * WT_b - 0.45 * TC_b$$
$$V_r = \quad - 0.13 * TT_r - 0.1 * WT_r - 0.45 * TC_r$$

where

V_i = observable utilities for mode i (a = auto, b = bus, r = light rail);
TT_i = in-vehicle travel time for mode i (minutes);
PT = parking time for auto (minutes);
WT_i = waiting time for mode i (minutes);
TC_i = out-of-pocket travel cost for mode i (dollars).

The values of each mode attribute are shown below.

	Mode		
Attribute	Auto	Bus	Light rail
Travel time (minutes)	20	35	30
Parking time (minutes)	5	-	-
Waiting time (minutes)	-	10	15
Out-of-pocket cost (dollars)	2.25	1.00	1.50

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

(b) To increase the number of bus riders, the bus company lowered the fare (i.e. out-of-pocket cost) to \$0.75 and reduced passengers' waiting time to 7 min. by increasing service frequency. Assume that the travel times 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)	4
	(b)	8
	(c)	4
	(d)	4
4	(a)	4
	(b)	12
	(c)	4
5	(a)	8
	(b)	8
	(c)	4
6	(a)	6
	(b)	12
	(c)	2
7	(a)	6
	(b)	6
	(c)	8