NATIONAL EXAMINATION DECEMBER 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 commercial land development and accessibility to transportation services are associated.

(b) List the factors that will potentially increase trip production at i) zonal level; ii) household level; and iii) person level (one factor for each level). Explain why.

(c) Describe the difference in factors affecting mode choice between work trips and shopping trips.

QUESTION 2:

A toll booth on a highway is open from 8:30 am. Vehicles are processed at a uniform rate of 12 veh/min. Vehicles start arriving at 8:00 am at a uniform rate of 4 veh/min. and continue to arrive at this rate until 8:30 am. From 8:30 am, the arrival rate becomes 8 veh/min.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from 8:00 am 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 for vehicles arriving from 8:30am to 9am.

QUESTION 3:

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

Trip rates (trips/household)

	Vehicles/household		
Persons/household	0	1	2 or more
1	2.6	4.0	4.0
2	4.8	6.7	8.2
3	7.4	9.2	11.2
4	9.2	11.5	14.7
5 or more	11.2	13.7	17.2

Forecasted number of households

	Vehicles/household		
Persons/household	0	1	2 or more
1	100	300	150
2	110	250	50
3	90	250	50
4	150	210	60
5 or more	20	50	30

(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 = – 0.85 + 2.63 * NPERSON + 2.01 * 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) Explain the effects of the number of persons per household and the number of vehicles per household 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:

At a particular time of a day, the traffic on a one-lane highway is flowing at a density of 10 veh/km. A free-flow speed is 120 km/hour and a capacity is 1800 veh/hour for this highway. Assume that a truck with a speed of 40 km/h enters the highway, travels for 2 km and exits the highway. When the truck enters the highway, all the cars immediately behind the truck are forced to lower their speed to 40 km/h. Assume the Greenshields' model applies, apply the shock wave theory to determine:

(a) The maximum density (jam density) 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 production from zone 3 is 1740. The trip attraction to zones 1, 2, 4 and 5 are 1080, 531, 47, and 82, respectively. The travel times from zone 3 to zones 1, 2, 4 and 5 are 20, 7, 10, and 25 minutes, respectively. Assume that the number of trips produced from zone 3 to zones 1, 2, 4 and 5 is inversely proportional to the square of inter-zonal travel time.

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

(b) Due to development of residential areas in zone 3 and expansion of service facilities in zones 1, 2, 4 and 5, the future trip production from zone 3 will increase to 2150 and the future trip attraction to zones 1, 2, 4 and 5 will increase to 1190, 692, 173, and 95, respectively. What will be the number of trips from zone 3 to zones 1, 2, 4 and 5? Assume that the inter-zonal travel times remain the same.

(c) Compare the number of trips from zone 3 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. Commuters can choose one of two major routes – Route 1 and Route 2. The travel time functions for the two routes are as follows:

$$t_1 = 12 + 0.01V_1,\ t_2 = 10 + 0.006V_2$$

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 volume from the residential zone to the commercial zone is 2,800 vehicles/hour.

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

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

$$t_3 = 10.2 + 0.006V_3$$

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 times on the three routes at a UE condition.

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

QUESTION 7:

Travellers can choose one of the following four modes of travel – automobile, bus, rail and bike. The utility functions for each mode are as follows:

$$V_i = -0.075 * AT_i - 0.05 * WT_i - 0.04 * RT_i - 0.002 * TC_i$$

where

V_i = observable utilities for mode i;
AT_i = access time for mode i (minutes);
WT_i = waiting time for mode i (minutes);
RT_i = riding time for mode i (minutes);
TC_i = out-of-pocket travel cost for mode i (cents).

The values of each mode attribute are shown below.

	Attribute			
Mode	Access time (minutes)	Waiting time (minutes)	Riding time (minutes)	Out-of-pocket cost (cents)
Auto	6	1	25	300
Bus	10	15	40	60
Rail	7	10	30	75
Bike	1	0	60	10

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

(b) The city will construct bike paths to encourage people to use bikes. The city expects that the paths will reduce riding time by bike to 45 min. Assume that the values of all other mode attributes remain the same as above. What will be the new share of each mode?

(c) Explain the independent of irrelevant alternatives (IIA) property of the multinomial logit model. Suggest how to overcome the limitations of the IIA property in predicting mode choice using the multinomial logit model.

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