NATIONAL EXAMINATION MAY 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) Discuss the interactions between commercial/residential land development and accessibility to transit services.

(b) Describe how traveller's mode choice is affected by trip purposes including work trips, shopping trips and recreational trips.

(c) List the assumptions of the gravity model applied for inter-zonal trip distribution. Explain the limitations of these assumptions.

QUESTION 2:

A section of a two-lane (one direction) freeway has the capacity of 1120 veh/hour/lane. The flow rate for this section is typically 1400 veh/hour. Assume that one of the two lanes is closed for 30 minutes and then re-opened.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) from the beginning of the lane closure 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 lane closure.

QUESTION 3:

Trip generation in one residential zone is estimated based on household trip rates and the forecasted household composition in a target year as shown below:

Trip rate (trips per household)

Automobiles per household	Persons per household				
	1	2	3	4	5 or more
0	2.6	4.8	7.4	9.2	11.2
1	4.0	6.7	9.2	11.5	13.7
2 or more	4.0	8.1	10.6	13.3	16.7

Forecasted number of households

Automobiles per household	Persons per household				
	1	2	3	4	5 or more
0	100	110	90	150	20
1	300	250	250	50	50
2 or more	150	50	50	60	0

(a) Calculate the forecasted number of trips for each household type (classified by persons per household and automobiles per household) in a target year.

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

Trip rate = -0.52 + 2.55 * PERSON + 1.75 * AUTO

where
PERSON = number of persons per household (5 or more = 5);
AUTO = number of automobiles per household (2 or more = 2).

Calculate the forecasted number of trips for each household type in 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 a one-lane road with the free-flow speed of 60 km/hour and capacity of 2160 veh/hour. Typically vehicles are traveling at a speed of 45 km/hour and a density of 36 veh/km in normal traffic conditions. On one day, a slow-moving vehicle with a speed of 10 km/h entered the road, travelled for 1.0 km and exited the road. Consequently, all the following vehicles had to lower the speed to 10 km/h behind the slow-moving vehicle. 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 slow-vehicle vehicle exited the road.

(c) The time it would take for the platoon to dissipate. Assume that there was no congestion on the road downstream of the exit point of the vehicle.

QUESTION 5:

Consider trip distribution within 5 zones in an area. The trip production from zones 1, 2, 3 and 4 are 1200, 1500, 1000, and 1700, respectively. The total trip attraction to zone 5 is 500. The travel distance from zones 1, 2, 3 and 4 to zone 5 are 7.5 km, 5 km, 10 km, and 12.5 km, respectively. Assume that the number of trips attraction to zone 5 is inversely proportional to the inter-zonal travel distance.

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

(b) Assume that the total trip attraction to zone 5 increased to 1000. Also, there is a new zone (zone 6) which produces 700 trips. The travel distance from zone 6 to zone 5 is 2.5 km. Estimate the number of trips from zones 1, 2, 3, 4 and 6 to zone 5 using the gravity model.

(c) List the potential factors affecting trip distribution other than travel distance.

QUESTION 6:

Consider Route 1 and Route 2 between two zones. Routes 1 and 2 do not overlap. The travel time functions for the two routes are as follows:

$$t_1 = 14 + \frac{V_1}{600},\ t_2 = 15 + \frac{V_2}{1400}$$

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 (veh/hour). The total commuter peak hour volume from the origin zone to the destination zone is 5,000 veh/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 3 has been suggested. Route 3 does not overlap with the two existing routes. This new route has the following travel time function:

$$t_3 = 16 + \frac{V_3}{2800}$$

where t_3 = travel time on Route 3 (minutes) and V_3 = volume on Route 3 (veh/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:

Auto: $V_a = 0.7 - 0.5 \cdot TC_b - 0.2 \cdot TT_a$
Bus: $V_b = 0.4 - 0.5 \cdot TC_b - 0.2 \cdot TT_a$
Light rail: $V_r = - 0.5 \cdot TC_b - 0.2 \cdot TT_a$

where
V_i = observable utility for mode i ;
TC_i = travel cost for mode i ($);
TT_i = travel time for mode i (minutes).

The travel time and cost for each mode are shown below.

Mode	TC	TT
Auto	$2.00	10 min
Bus	$0.75	18 min
Light rail	$1.25	15 min

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

(b) In the part (a), assume that the auto mode is classified into two different modes – auto-drive (drive alone) and auto-passenger (shared ride or carpool). The travel time for both modes is equal (= 10 min.) and the travel costs of auto-driver and auto-passenger are $2.00 and $1.00, respectively. Calculate the shares of the four modes using a 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 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)	4
	(b)	12
	(c)	4
5	(a)	8
	(b)	8
	(c)	4
6	(a)	6
	(b)	10
	(c)	4
7	(a)	6
	(b)	6
	(c)	8