NATIONAL EXAMINATION MAY 2015

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 residential development in low-density suburban areas affects mode choice and travel distance of work trips.

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

QUESTION 2:

A section of a two-lane (one direction) freeway has the capacity of 18 veh/min. The flow rate for this section is typically 12 veh/min. Assume that the road was completely closed for 10 minutes due to an accident. One of the two lanes was open for 25 minutes during which the accident was being cleared but the capacity was reduced to 6 veh/min during this time period. Afterwards, two lanes were fully open.

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

QUESTION 3:

The following tables show household trip rates and the forecasted household composition in a target year for a residential zone:

Trip rate (trips per household)

Number of cars in household	Number of workers in household			
	0	1	2	3 or more
0	0.9	2.1	3.4	5.3
1	3.2	3.5	3.7	8.5
2 or more	-	4.1	4.7	8.5

Forecasted number of households

Number of cars in household	Number of workers in household			
	0	1	2	3 or more
0	120	80	60	30
1	50	210	270	240
2 or more	-	40	70	190

(a) Calculate the forecasted number of trips for each household type (classified by number of workers in household and number of cars in 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 = 0.77 + 1.60 * WORKER + 1.06 * CAR

where
WORKER = number of workers in household (3 or more = 3);
CAR = number of cars in household (2 or more = 2).

Describe the effects of number of workers and number of cars in household on the trip rate.

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

(c) Discuss the difference in estimating the forecasted number of trips between the two methods used in (a) and (b) in terms of underlying assumptions and limitations.

QUESTION 4:

Consider a one approach at a signal-control intersection with a free-flow speed of 60 km/hour and a capacity of 1200 veh/hour. Typically vehicles are approaching the intersection at a speed of 45 km/hour and a density of 20 veh/km in normal traffic conditions. They are required to stop during the red interval. The duration of red interval is 30 seconds per cycle. 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 queue during the red interval.

(c) The time it would take for the queue to dissipate after the end of red interval. Assume that there was no congestion downstream of the intersection.

QUESTION 5:

Consider trip distribution between 2 zones in an area. The total trip productions from zones 1 and 2 are 150 and 150, respectively. The total trip attractions to zones 1 and 2 are 100 and 200, respectively. The travel distance between zone 1 and zone 2 is 5 km. The travel distance within the same zone is 2 km.

(a) Estimate the number of intra-zonal and inter-zonal trips using the following gravity model:

$$T_{ij} = \frac{O_i D_j / d_{ij}^2}{\sum_{j=1}^{n} \left(D_j / d_{ij}^2\right)}$$

where
T_{ij} = number of trips from zone i to zone j;
O_i = total trip production from zone i;
D_j = total trip attraction to zone j;
d_{ij} = travel distance between zone i and zone j;
n = total number of destination zones.

(b) Assume that the total trip productions from zones 1 and 2 will increase to 200 and 200, respectively, in a target year. The total trip attractions to zones 1 and 2 will also increase 150 and 250, respectively. The intra-zonal and inter-zonal travel distances remain the same. Estimate the forecasted number of intra-zonal and inter-zonal trips in the target year using the gravity model in part (a).

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

QUESTION 6:

Consider a town served by a bypass route and a town-centre route which connect the origin A to the destination B. There are 4,000 vehicles/hour from A to B in a peak hour. The travel time functions for the two routes are as follows:

$$t_b = 15 + 0.005V_b \text{, } t_{t1} = 10 + 0.02V_{t1}$$

where t_b and t_{t1} = travel times on the bypass route and the town-center route, respectively (minutes), and V_b and V_{t1} = volumes on the bypass route and the town-center route, respectively (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 the bypass and town-centre routes, an alternative town-centre route has been added. The alternative route does not overlap with the two existing routes. This new route has the following travel time function:

$$t_{t2} = 12 + 0.02V_{t2}$$

where t_{t2} = travel time on the alternative town-centre route (minutes) and V_{t2} = volume on alternative town-centre route (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 two travel modes for work trips – car and bus. The following utility functions for travel by each mode have been estimated:

Car: $V_c = 0.35 - 0.025TT_c - 0.042ET_c - 0.01TC_c$
Bus: $V_b = -0.025TT_c - 0.042ET_c - 0.01TC_c$

where

V_i = observable utility for mode i ;
TT_i = travel time for mode i (min);
ET_i = access time for mode i (min);
TC_i = travel cost for mode i ($).

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

Mode	TT	ET	TC
Car	25 min	5 min	$1.40
Bus	40 min	8 min	$0.50

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

(b) In the part (a), assume that the car mode is classified into two different modes – car-drive (drive alone) and car-passenger (shared ride or carpool). The travel time and access time are equal for both modes. The travel costs of car-driver and car-passenger are $1.40 and $0.70, respectively. Calculate the shares of the three 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.

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Marking scheme:

Question	Sub-questions	Marks
1	(a) (b) (c)	7 7 6
2	(a) (b) (c)	10 4 6
3	(a) (b) (c)	7 9 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