National Examination December 2016

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 the interaction between commercial land development and transportation.

(b) Explain how interrelationships among industry, household and local service sectors affect spatial distributions of these sectors and transportation.

(c) 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.

QUESTION 2:

Consider a toll booth where vehicles start arriving at 8:00 am at a rate of 40 vehicles/min. The toll booth processes vehicles at a rate of 20 vehicles/min at 8:00 am-8:15 am and then at a rate of 60 vehicles/min at 8:15 am and thereafter.

(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) and the maximum waiting time in the queue.

(c) Calculate 1) the total vehicle delay and 2) the average delay per vehicle.

QUESTION 3:

Trip generation in a traffic zone is predicted based on the household size and vehicle ownership of sample households selected for the travel survey as follows:

Trip rates (trips/household)

	Vehicles/household		
Persons/household	0	1	2+
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+	11.2	13.7	17.2

(a) Calculate the forecasted number of trips for each household size and vehicle ownership for a target year if the number of households is forecasted as follows.

Forecasted number of households in a target year

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

(b) Alternatively, the above travel survey data were used to calibrate the following linear regression equation for the expected trip generation rate by a household:

Trip rate = -0.85 + 2.6289 * NPERSON + 2.0115 * 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 size and vehicle ownership 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:

Consider a single-lane highway with the free-flow speed of 100 km/h and the jam density of 100 vehicles/km. In normal traffic condition, vehicles are travelling at the speed of 80 km/h. On one day, a truck with the speed of 15 km/h entered the highway, traveled 1.0 km at the same speed and exited the highway. Consequently, the vehicles immediately behind the truck had to lower the speed to 15 km/h behind the truck and formed a platoon with the density of 85 vehicles/km and the flow of 1275 vehicles/h. Determine the followings using the Greenshields' model or the shock wave theory:

(a) The capacity and density at capacity of the vehicle flow.

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

(c) The time it took for the platoon to dissipate after the truck exited. Assume that there was no congestion on the road further downstream of the point where the truck exited.

QUESTION 5:

Consider two zones – zone 1 and zone 2. The total trip productions from both zones 1 and 2 are 75. The total trip attractions to zones 1 and 2 are 50 and 100, respectively. The travel time between zone 1 and zone 2 (inter-zonal) is 5. The travel time within the same zone (intra-zonal) is 2.

(a) Estimate the number of intra-zonal and inter-zonal trips using the gravity model. The friction factor between zone i and zone j (F_{ij}) is defined as follows:

$$F_{ij} = \frac{1}{t_{ij}} \qquad \text{where } t_{ij} = \text{travel time between zone } i \text{ and zone } j;$$

(b) Assume that the total trip productions from both zones 1 and 2 will increase to 125 in a target year. The total trip attractions to zones 1 and 2 will also increase to 75 and 175, respectively, in a target year. The intra-zonal and inter-zonal travel times remain the same. Estimate the forecasted number of intra-zonal and inter-zonal trips in the target year using the gravity model.

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

QUESTION 6:

Consider the commuter work trips from the residential zone in a suburban area to the commercial zone in a downtown during the morning peak period. There are two major routes – Routes 1 and 2. These two routes do not overlap each other. Assume that the travel time functions for these two routes are as follows:

$$t_1 = 22 + 2\left(\frac{V_1}{225}\right), \quad t_2 = 12 + \left(\frac{V_2}{100}\right)$$

where t_i = travel times on Route i (minutes), and V_i = volume on Route i (vehicles/hour). Assume that the total 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 called Route 3 will be added. Route 3 does not overlap with the two existing routes. This new route has the following travel time function:

$$t_3 = 14 + 4\left(\frac{V_3}{225}\right)$$

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. Did the new route reduce travel time at the UE condition?

(c) In this question, it was assumed that drivers always take the shortest path. Discuss the limitation of this assumption and how you would overcome the limitation in this route choice problem.

QUESTION 7:

Consider a mode choice model for work trips. There are three available modes of travel (auto, bus and light rail). The observable utility functions were specified as follows:

Auto: $V_a = 1.1 - 0.05 \cdot TT_a - 0.25 \cdot TC_a$
Bus: $V_b = 0.1 - 0.05 \cdot TT_b - 0.25 \cdot TC_b$
Light rail: $V_r = - 0.05 \cdot TT_r - 0.25 \cdot TC_r$

where,

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

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

Mode	TT	TC
Auto	16 min	$3.50
Bus	30 min	$2.00
Light rail	25 min	$2.50

(a) Calculate the shares of the three modes using the multinomial logit model.

(b) In the part (a), the bus company plans to lower bus fare from $2.00 to $1.00 to increase its mode share for work trips. Assume that bus fare is the only cost of travel for bus. Predict the shares of the three modes after the bus fare reduction.

(c) The result in part (b) may not make intuitive sense due to unrealistic assumption of the logit model. Explain this assumption of the logit model and how you would account for such unrealistic assumption in this mode choice problem.

Marking scheme:

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