NATIONAL EXAMINATION DECEMBER 2010

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) Describe the advantage(s) and disadvantage(s) of using a household-based trip generation model rather than a zone-based trip generation model.

(b) Give two examples of travel demand management strategies to increase average vehicle occupancy during commuter peak hours. Explain how these strategies would change travel patterns and travel time.

(c) Multinomial logit models are commonly used to predict mode choices (e.g., car, bus and light rail) made by travelers in transport planning. However, this type of models may yield unrealistic results of mode choice in some cases due to its assumption of independent of irrelevant alternatives (IIA). Explain why the IIA assumption may not be valid in some real world situations.

QUESTION 2:

Consider a freeway with two lanes in each direction. The freeway has a normal capacity of 3,600 vehicles/hour. On one day, due to a minor collision, one of the two lanes was blocked at 8:15 am and the capacity was reduced to 1,800 vehicles/hour. Typical arrival flow rate at this time of day is 2,520 vehicles/hour. The lane blockage was removed at 8:30 am and the capacity returned to normal thereafter.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) and determine the time when the queue caused by the collision clears.

(b) Calculate the maximum queue length (maximum number of vehicles in the queue).

(c) Calculate the longest waiting time of the vehicle that arrives after the collision occurred.

(d) Calculate 1) the total vehicle delay and 2) the average delay per vehicle for vehicles arriving during 8:15 am - 8:45 am.

QUESTION 3:

The number of households and the number of trips produced from each household type (categorized by household size and income) were observed from a survey in a city as shown in the table below.

Survey data

	Household size					
	1		2		3+	
Household income	No. of HH	No. of Trips	No. of HH	No. of Trips	No. of HH	No. of Trips
Low	500	1220	450	1300	500	1950
Medium	600	1860	700	2950	800	3700
High	500	2125	800	4500	750	3600

The following table summarizes the forecasted household composition in a target year in the city.

Forecasted number of households

	Household size		
Household income	1	2	3+
Low	35	69	47
Medium	50	83	29
High	71	23	16

(a) Calculate the forecasted number of trips for each household type (classified by household size and income) for a target year.

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

Trip rate = 0.99 + 0.91 * INCOME + 0.59 * SIZE

where
INCOME = household income (1 = Low, 2 = Medium, 3 = High);
SIZE = household size (if 3 or more, SIZE = 3).

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

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

QUESTION 4:

Traffic flow on a one-lane road section (no passing is allowed) has the capacity of 1,000 vehicles/hour and free-flow speed of 40 km/hour. There exists a railway grade crossing at the end of the road section. On one day, a train is passing through the crossing and the gate is closed. Consequently the vehicles are required to stop behind the gate while the train is passing. Three minutes later, the gate is opened and the vehicles immediately start moving again.

(a) Calculate the jam density and the density at capacity (critical density) using the Greenshields' model. Sketch the flow-density graph and show the values of capacity, jam density, and critical density in the graph.

(b) Traffic flow in normal traffic condition is characterized by a volume of 640 vehicles/hour and a density of 20 vehicles/km. Using the shock wave theory, determine the length of the platoon when the gate is opened.

(c) Determine how long it would take for the platoon to dissipate after the gate is opened. Assume that there is no congestion on the road downstream of the crossing.

QUESTION 5:

A group of investors proposed to develop large shopping facilities at a vacant site. It is expected that in the long run, the facilities will attract the people who live or work in the three neighboring residential and commercial zones 1, 2 and 3. The total trip attraction to the facilities from the three zones is 1,000 trips per day. The travel distances from zones 1, 2 and 3 to the facilities are 3 km, 4 km and 5 km, respectively. Total numbers of daily trips produced from zones 1, 2 and 3 are 4,500, 6,000 and 7,500, respectively. Assume that the number of trips from zones 1, 2 and 3 to the facilities follows a gravity model with a friction factor that is inversely proportional to the square of the travel distance from an origin zone to the facilities.

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

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

(c) Discuss the limitations of the gravity model.

QUESTION 6:

Consider the commuter work trips from the residential area to the work places in the commercial area during the morning peak period. There are two major routes – Route 1 and Route 2. Assume that the volume-delay functions for these two routes are as follows:

$$t_1 = 45 + 90\left(\frac{V_1}{1500}\right),\ t_2 = 30 + 45\left(\frac{V_2}{1000}\right)$$

where t_1 and t_2 = travel times in minutes for Routes 1 and 2, respectively, and V_1 and V_2 = volumes in vehicles per hour for Routes 1 and 2, respectively. Assume that the total peak hour volume from the residential area to the commercial area is 2,000 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 - Route 3 - has been suggested. Route 3 does not overlap with Routes 1 and 2. This new route has the following volume-delay function:

$$t_3 = 35 + 80\left(\frac{V_3}{1000}\right)$$

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 the UE conditions.

(c) Describe the two assumptions of the UE conditions.

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 ($).

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

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

(b) 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 and the travel times of all modes are the same as in part (a). Predict the shares of the three modes after the bus fare reduction.

(c) Describe at least two other factors that might affect mode choice, but are not directly related to mode attributes (e.g. travel time and travel cost).

Marking scheme:

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