NATIONAL EXAMINATION MAY 2013

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) Give one example of land use-transportation interaction. Explain the effect of such interaction on travel demand.

(b) Consider prediction of travelers' route choice based on travel time using a multinomial logit (MNL) model. However, if two or more routes are overlapped, the MNL model may yield unrealistic results of route choice due to the assumption of the models. Explain why the MNL model may not be valid in this case and how the limitation of the assumption in the model can be overcome.

(c) Describe the difference between a supply-side solution and a demand-side solution for transportation problems. Provide one example for each.

QUESTION 2:

Loaded trucks start arriving at a loading dock at 8:00 am at arrival rates of 8 trucks per minute from 8:00 to 8:30 am and 3 trucks per minute thereafter. The loading dock opens at 8:15 am 6 trucks per minute for unloading and departure.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) for the truck arrival and departure from 8:00 am until the queue clears. Find the time when the queue clears after the loading dock is open.

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

(c) Calculate the longest waiting time of the truck which arrives at the loading dock.

(d) Calculate 1) the total truck delay and 2) the average delay per truck from 8:00 am until the queue clears.

QUESTION 3:

A travel survey was conducted to estimate trip generation in one study area. A sample of 56 households was interviewed and the survey data are summarized in the following table:

Number of sample households

	Automobile ownership					
	0		1		2 or more	
Household size	No. of households	No. of trips	No. of households	No. of trips	No. of households	No. of trips
1	5	30	3	12		
2	3	21	8	46	3	24
3	2	15	5	42	5	52
4	4	34	2	20	5	55
5 or more			3	33	8	96

The forecasted number of households in the study area for a target year is shown below.

Forecasted number of households

	Automobile ownership		
Household size	0	1	2 or more
1	500	425	75
2	375	725	225
3	350	525	475
4	50	250	550
5 or more	25	200	775

(a) Calculate the trip generation rate by a household and the forecasted number of trips for each household type (classified by household size and automobile ownership) for a target year.

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

Trip rate = 3.31 + 1.43 * HSIZE + 0.84 * AUTO

where
HSIZE = household size (= 5 if 5 or more);
AUTO = automobile ownership (=2 if 2 or more).

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

(c) Compare underlying assumptions and limitations of the methods used in (a) and (b).

QUESTION 4:

Traffic flow on an one-lane road in normal conditions is characterized by a speed of 60 kilometres/hour and a density of 20 vehicles/kilometre. The capacity of the road is 1500 vehicles/hour and the free-flow speed is 75 kilometres/hour. On one day, one vehicle suddenly lost power and became stalled on the road. Thus, all the following vehicles had to stop behind the stalled vehicle. Four minutes later, the stalled vehicle regained power and started moving again. Apply the Greenshields' model or the shock wave theory to determine:

(a) The jam density and the density at capacity.

(b) The length of the platoon immediately after the vehicle started moving again.

(c) The time it would take for the platoon to dissipate after the vehicle started moving again. Assume that there is no congestion on the road further downstream of the vehicle.

QUESTION 5:

New shopping facilities are planned for an urban district (zone "S"). It is expected that the facilities will attract the people who lives in the three neighboring residential zones 1, 2 and 3. The total trip attraction to the zone S from the three zones is 2000 trips per day. The travel times from zones 1, 2 and 3 to the zone S are 20, 25 and 40 minutes, respectively. Total numbers of daily trips produced from zones 1, 2 and 3 are 5000, 6500 and 8000 trips per day, respectively. Assume that the number of trips from zones 1, 2 and 3 to the zone S follows a gravity model with a travel time factor or friction factor that is inversely proportional to the travel time from the zones to the zone S.

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

(b) Due to expansion of shopping facilities in the zone S and population growth in the three residential zones, the future trip attraction to the zone S will increase to 2500 trips per day and the future trip production from zones 1, 2 and 3 will increase to 5850, 7475 and 9200 trips per day, respectively in a target year. Estimate the forecasted number of trips from zones 1, 2 and 3 to the zone S in the target year. Assume that the travel times from zones 1, 2 and 3 to the zone S remain the same.

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

QUESTION 6:

Consider two major routes – Routes 1 and 2 – which connect two zones. The travel time functions for the two routes are as follows:

$$t_1 = 22 + \frac{2V_1}{225}, \; t_2 = 12 + \frac{V_2}{100}$$

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 number of trips from one zone to the other zone is 7200 vehicles/hour.

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

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

$$t_3 = 14 + \frac{4V_3}{225}$$

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? Explain why.

QUESTION 7:

Consider three travel modes for work trips – automobile, bus and light rail. The utility function for travel by each mode is described as follows:

$$V = \alpha + \beta_1 * IVTT + \beta_2 * OVTT + \beta_3 * TC$$

where

V = observable utilities;
$IVTT$ = in-vehicle travel time (minutes);
$OVTT$ = out-of-vehicle travel time (minutes);
TC = travel cost (dollars).

The calibrated utility functions include the following parameter values:

Mode	α	β_1	β_2	β_3
Automobile	0.3	-0.04	0.2	0.06
Bus	0.5	-0.06	0.2	0.06
Light rail	0	-0.06	0.2	0.06

(a) Based on the coefficients (β's) in the above utility function, explain the effects of in-vehicle travel time, out-of-vehicle travel time and travel cost on a driver's preference towards each mode. Do they make intuitive sense?

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

Mode	In-vehicle travel time (minutes)	Out-of-vehicle travel time (minutes)	Travel cost (dollars)
Automobile	12	7	2.50
Bus	20	12	0.75
Light rail	18	10	1.20

(c) The City considers the construction of a new parking lot to improve automobile drivers' accessibility to workplaces. The City expects that the new parking lot will reduce out-of-vehicle travel time and travel cost for automobiles to 5 minutes and $2.00, respectively. Assume that all other conditions are unchanged. What percentage of increase in share of automobiles is expected due to the new parking lot compared to (b)?

Marking scheme:

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