

NATIONAL EXAMINATION MAY 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) Give two examples of travel demand management strategies to reduce congestion during commuter peak hours. Explain the impacts of the strategies on travel patterns and travel time.
- (b) Explain why work trips and non-work trips (e.g. shopping, recreation) are different in terms of trip length and temporal distribution.
- (c) Explain how the increased density of residential land use will increase transit use and how increased transit use will encourage dense residential land development.

QUESTION 2:

Loaded trucks start arriving at a loading dock at 8:00 am at arrival rates of 6 trucks per minute from 8:00 to 8:30 am and 2 trucks per minute thereafter. The loading dock opens at 8:15 am and can handle 5 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:

The following tables show the data collected from the household survey for three zones A, B and C:

Zone	No. of households	Residents	Workers	Income
A	10,000	2.0	1.0	low
B	20,000	3.0	2.0	low
C	40,000	2.5	2.0	high

- (a) Assume that household trip generation model was estimated using a linear regression model as follows:

$$\text{Trip rate} = 0.2 + 0.5 * \text{NWORK} + 1.1 * \text{INC}$$

Where

Trip rate = no. of trips per household for a given zone;

NWORK = no. of workers per household;

INC = a dummy variable of income level (1 = high, 0 = low).

Calculate the number of trips for each zone using the above model.

- (b) Suppose a cross-classification model was developed, which classified households based on household income (low and high) and number of workers in household (1 or less and 2 or more workers per household). The trip rates are shown as follows:

Trip rate (no. of trips per household)

No. of workers	Income	
	Low	High
1 or less	0.8	1.0
2 or more	1.2	2.3

Calculate the number of trips for each zone using the above cross-classification method.

- (c) If the actual number of trips generated by three zones are as follows, which of the two methods in (a) and (b) is the best? Explain your answer.

Zone	No. of trips
A	8,200
B	24,000
C	92,000

QUESTION 4:

Traffic flow on a section of a single-lane highway can be described by the Greenshields' model. The free-flow speed is 80 km/hour and the jam density is 75 vehicles/km.

- (a) Calculate the capacity, critical speed (speed at capacity) and critical density (density at capacity). Sketch the volume-speed graph and show the values of free-flow speed, critical speed and capacity in the graph.
- (b) In normal traffic conditions, traffic flows at a rate of 1200 vehicles/hour and a speed of 75 km/hour. A truck with a speed of 35 km/hour enters the highway, travels for 3.5 km and exits the highway. The cars immediately behind the truck are forced to lower the speed to 35 km/hour and form a platoon with a density of 40 vehicles/km and a flow rate of 1400 vehicles/hour. Determine the length of the platoon when the truck exits the highway using shock wave theory.
- (c) Following part (b), determine how long it would take for the platoon to dissipate after the truck exits. Assume that there is no congestion on the highway downstream of the exit point of the truck.

QUESTION 5:

New commercial facilities are planned for an urban district. It is expected that the facilities will attract the people who lives in the three neighboring residential zones A, B and C. The total trip attraction to the facilities from the three zones is 1500 trips per day. The travel times from zones A, B and C to the facilities are 30, 40 and 50 minutes, respectively. Total numbers of daily trips produced from zones A, B and C are 4500, 6000 and 7500, respectively. Assume that the number of trips from zones A, B and C to the facilities 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 facilities.

- (a) Estimate the number of trips from zones A, B and C to the facilities using the gravity model.
- (b) List the potential factors affecting trip distribution other than travel time.
- (c) Describe the assumptions of the gravity model.

QUESTION 6:

Consider the trips from the zone 1 to the zone 2. There are two major routes – Route A and Route B. The travel time functions for the two routes are as follows:

$$t_A = 45 + \frac{3q_A}{50}, \quad t_B = 30 + \frac{9q_B}{200}$$

where t_A and t_B = travel times on Routes A and B, respectively (minutes), and q_A and q_B = volumes on Routes A and B, respectively (vehicles/hour). The total number of trips from zone 1 to zone 2 is 2000 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 A and B, the new route, Route C is proposed. This new route does not overlap with the two existing routes. Route C has the following travel time function:

$$t_C = 35 + \frac{2q_C}{25}$$

where t_C = travel time on Route C (minutes) and q_C = volume on Route C (vehicles/hour). Compute the new traffic volumes and travel times on the three routes at a UE condition.

QUESTION 7:

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

$$V_a = 0.5 - 0.1 * IVTT_a - 0.2 * OVTT_a - 0.0007 * \frac{OPTC_a}{INC} + 0.25 * AO$$

$$V_b = 0.25 - 0.11 * IVTT_b - 0.2 * OVTT_b - 0.0007 * \frac{OPTC_b}{INC}$$

$$V_r = -0.12 * IVTT_r - 0.2 * OVTT_r - 0.0007 * \frac{OPTC_r}{INC}$$

where

- V_i = observable utilities for mode i (a = auto, b = bus, r = light rail);
- $IVTT_i$ = in-vehicle travel time for mode i (minutes);
- $OVTT_i$ = out-of-vehicle travel time for mode i (minutes);
- $OPTC_i$ = out-of-pocket travel cost for mode i (cents);
- INC = trip maker's income (1 = low, 2 = medium, 3 = high);
- AO = no. of vehicles in the trip maker's household (1 = one or less, 2 = two or more vehicles).

- (a) Explain the effects of travel time, travel cost, income and no. of vehicles in the household on a driver's preference towards each mode. Do they make intuitive sense?
- (b) The following table shows the travel time and cost for each mode. Calculate the probability of choosing each mode for the person with medium income and one vehicle in the household using the multinomial logit model.

Mode	In-vehicle travel time (minutes)	Out-of-vehicle travel time (minutes)	Travel cost (cents)
Automobile	20	5	250
Bus	25	10	50
Light rail	22	12	120

- (c) Following part (b), the light rail company plans to attract more passengers. Thus, the company will realign railways to reduce travel time and run more trains to reduce passengers' waiting time. After this improvement, it is expected that in-vehicle travel time and out-of-vehicle travel time by light rail will be reduced to 20 and 10 minutes, respectively. Assume that the travel cost will not change. Predict the probability of choosing each mode.
- (d) Does the result in (c) make intuitive sense? Comment on the result based on the independent of irrelevant alternatives (IIA) property of the multinomial logit model and suggest how to overcome the limitations of the IIA property in this mode choice problem.