NATIONAL EXAMINATION MAY 2009

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: Short Questions

(a) Explain how land use and transportation interact and why this interaction is important for travel demand forecasting?

(b) Explain how the costs and benefits of the transportation planning projects (e.g. highway construction, land development) can be measured quantitatively. Discuss how the best transportation planning alternative can be selected based on the costs and benefits of a set of alternatives.

(c) Describe the advantages and disadvantages of the cross-classification analysis as compared to linear regression in predicting trip generation.

QUESTION 2:

Speed and density have an inverse relationship (i.e. as density increases, speed decreases and vice versa) for a continuous flow on highways. Assume that their relationship is described in the following linear function:

$$u = 90 - 0.9\,k$$

where u = speed in kilometre per hour and k = density in vehicles per kilometre.

(a) Calculate the free-flow speed and the jam density.

(b) Calculate the capacity and the speed at capacity using the fundamental relationship among speed, flow and density. Plot the speed-flow (in vehicles per hour) diagram and show the congested and uncongested regimes in the diagram.

(c) Determine whether the following factors will increase or decrease the highway capacity. Briefly explain why.

1. Higher percentage of heavy vehicles (e.g. trucks, buses);
2. Narrower width of lanes;
3. More lanes;
4. Higher interchange density (or more number of interchanges per unit length);
5. Steeper upgrade.

QUESTION 3:

Vehicles in a single approach arrive at a signalized intersection at a rate of 12 vehicles per minute. The signal has a 60-second cycle time with a 30-second green interval and a 30-second red interval (ignore yellow interval). Assume that all the vehicles in the queue formed on red pass through the intersection during the subsequent green interval at the saturation flow rate of 30 vehicles per minute. Thus, the queue does not spill over to the next cycle. Ignore driver reaction time and vehicle acceleration time at the start of the green interval.

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) for the approach in one cycle (60 seconds). Find the time when the queue clears after the start of the green interval.

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

(c) Calculate the waiting time of the vehicle that arrives at the end of red interval.

(d) For one cycle, calculate 1) the total vehicle delay and 2) the average delay per vehicle.

QUESTION 4:

Traffic on a single-lane highway (no passing is allowed) is travelling at 40 kilometres per hour with a density of 25 vehicles per kilometre. The capacity of the highway is 1400 vehicles per hour and the free-flow speed is 50 kilometres per hour. On one day, debris falls on the road and blocks the lane. Consequently, all vehicles behind the debris must stop. The debris is removed 5 minutes after it falls on the road. Assume that the vehicles start moving again immediately after the debris is removed.

(a) Calculate the jam density and the density at capacity using the Greenshields' model.

(b) Determine the length of the platoon immediately after the debris is removed using shock wave theory.

(c) Determine how long it would take for the platoon to dissipate after the debris is removed using shock wave theory. Assume that there is no congestion on the road further downstream of the debris.

QUESTION 5:

There are 4 zones in an area. The total trip attraction to zone 1 is 1000. The distance from zones 2, 3 and 4 to zone 1 is 3 kilometres, 4 kilometres and 5 kilometres, respectively. The trip production of zones 2, 3 and 4 is 3000, 4000 and 5000, respectively. Assume that the number of interzonal trips from a given zone to zone 1 is directly proportional to the trip production of the zone and the trip attraction of zone 1, and inversely proportional to the square of the distance from the zone to zone 1.

(a) Calculate the number of trips from zones 2, 3 and 4 to zone 1 using the gravity model.

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

(c) Discuss the limitation of the gravity model.

QUESTION 6:

There are currently two routes from traffic zone A to traffic zone B called "route 1" and "route 2". The travel time functions for the two routes are as follows:

$$t_1 = 1.50 + 30\left(\frac{q_1}{2000}\right), \quad t_2 = 4.25 + 25\left(\frac{q_2}{2000}\right)$$

where t_1 and t_2 are travel times on routes 1 and 2, respectively (min), and q_1 and q_2 are volumes on routes 1 and 2, respectively (vehicles per hour). A total volume from zone A to zone B is 4400 vehicles per hour.

(a) What will be the traffic volume and travel time on the two routes at the user-equilibrium (UE) condition?

(b) To relieve the congestion on the existing two routes, a new route called "route 3" will be built. The travel time function for route 3 is as follows:

$$t_3 = 0.40 + 16\left(\frac{q_3}{2000}\right)$$

where t_3 is travel time on route 3 (minutes) and q_3 is volumes on routes 3 (vehicles per hour).

What will be the new traffic volumes and travel time on the three routes at the UE conditions? Will the equilibrium travel time increase or decrease after route 3 is open?

QUESTION 7:

Suppose there are three travel modes – automobile, bus and light rail. A calibrated utility function for each mode is as follows:

$$V_a = -0.30 - 0.002 * TC_a - 0.05 * TT_a$$

$$V_b = -0.35 - 0.002 * TC_b - 0.05 * TT_b$$

$$V_r = -0.40 - 0.002 * TC_r - 0.05 * TT_r$$

where V_a, V_b and V_r = observable utilities for auto, bus and light rail, respectively; TC_a, TC_b and TC_r = cost of travel (cents) for auto, bus and light rail, respectively; TT_a, TT_b and TT_r = travel time (minutes) for auto, bus and light rail, respectively. The travel cost and travel time for each mode is shown below.

Mode	Travel cost (cents)	Travel time (minutes)
Automobile	200	30
Bus	100	40
Light rail	150	45

(a) Calculate the share of each mode (i.e. modal split) using the multinomial logit model.

(b) In the part (a), if the fare of light rail is reduced to 75 cents, what would be the share of each mode?

(c) Since both bus and light rail are public transportation modes, the choice of these two modes is likely to be correlated. Explain how the multinomial logit model will yield unrealistic results of modal split due to this correlation in part (b).

Marking scheme:

Question	Sub-questions	Marks
1	(a) (b) (c)	7 7 6
2	(a) (b) (c)	4 11 5
3	(a) (b) (c) (d)	8 4 4 4
4	(a) (b) (c)	4 8 8
5	(a) (b) (c)	12 4 4
6	(a) (b)	6 14
7	(a) (b) (c)	6 6 8