NATIONAL EXAMINATION DECEMBER 2008

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:

The relationship between speed (u, km/hr) and density (k, veh/km) for an upgrade section of a highway is assumed to have the following form:

$$u = a\,(k-b)^2$$

It is also known that the jam density is 120 vehicles per kilometre and free-flow speed is 80 km per hour.

a) What is the optimal density of this highway section (i.e., density at capacity)?

b) When the traffic on this highway section is moving at a space mean speed of 50 km/h, a large truck enters the section which can only maintain a climbing speed of 30 km/h. Because passing is not permitted at this section, a platoon is built up behind the truck. What would be the length of the platoon if the situation continues for 1 minute?

c) Use the fundamental diagrams to explain why flow rate (q) is not a good measure of traffic conditions?

QUESTION 2:

Travel time functions (or link performance functions) such as BPR function are commonly used to estimate the travel time effects of congestion on individual links (roadways) in a demand forecasting process (e.g., traffic assignment). You are asked to derive a travel time function for a signal controlled link with the following settings:

- The link has a length of L (km) with a constant traffic flow rate of x (pcu/hr);
- Traffic on the section (except the queue portion at the signalized approach) follows a Greenshields model with a known free-flow speed of u_f (km/hr) and a jam density of k_j (pcu/km);
- The link is controlled by a signal with a cycle length of C (sec) and an effective green duration of G (sec) and a saturation flow rate of s (pcu/hr)

a). Derive an equation for the average cruising travel time on this link (excluding delay caused by the signal)p;

b). Derive an equation for average queueing delay caused by the signal;

QUESTION 3: Short Questions

a). What are the fundamental assumptions behind Wardrop's user equilibrium traffic system?

b). What is highway capacity? Give three examples on why it is an important value to estimate?

c). What is highway level of service? Give three examples on factors that influence highway level of service?

d). For travel demand forecasting, what is the major motivation for activity-based models?

e). What is the definition of Peak Hour Factor (PHF)?

QUESTION 4:

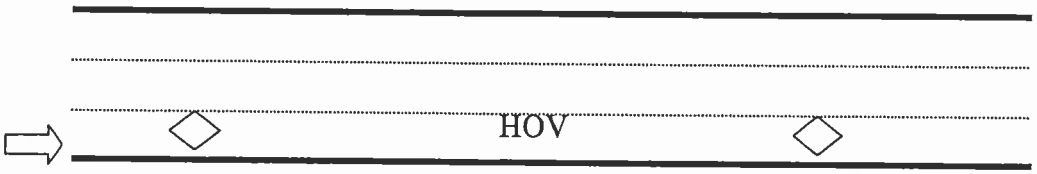
The transit line between a suburban area and downtown area in a large city is currently carrying 1,500 passenger rides per day, charging $1.50 per ride. The route has a cycle time of 120 minutes and currently has a service headway is 30 minutes. A market study has shown that the fare elasticity and service frequency elasticity are -2.0 and 0.1 respectively. The management proposes to increase the service frequency from two to four buses per hour and increase fare from $1.50 to $2.00 per ride.

a) Will the total fare revenue of this transit line increase? Why or why not?

b) In order to make a comprehensive evaluation of this proposal, what costs and benefits should be considered?

QUESTION 5:

An urban freeway corridor has three lanes (one-way), one of which is set as a high occupancy vehicle (HOV) lane that can be used only by vehicles with two or more occupants, and two of which are unrestricted – open to all vehicles.



The performance function for each lane of this highway is

$$t = 10(1 + 0.1\frac{x}{C})$$

Where t is the travel time in minutes; x is the lane traffic volume in vehicles per hour and C is lane capacity, equal to 2000 vehicles per hour.

During the peak hour, 5,000 vehicles with one occupant and 2,000 vehicles with two occupants enter this freeway corridor for the destination.

a). Determine the UE distribution of traffic among lanes.

b). What would be the lane traffic distribution if 40% of the single occupant vehicles switch to carpool with an assumed car occupancy of two?

QUESTION 6:

A consultant was trying to calibrate a doubly-constrained gravity model for a four zone study area based on the following observations:

Base-year observed trip matrix

Zone	1	2	3		Total
1	0	50	200	200	450
2	0	0	100	300	400
3	0	0	0	500	500
4	0	0	0	100	100
Total	0	50	300	1100	1450

Base-year observed travel time (min)

Zone	1	2	3	4
1	5	10	20	30
2	10	5	10	20
3	20	10	5	10
4	30	20	10	5

The engineer started the calibration procedure by assuming the following travel-time (friction) factor

$$F_{ij} = t_{ij}^{-1.0}$$

a). Calculate the trip distribution between individual zones (max. of 2 iterations in matrix balancing)

b). How would you evaluate the calibration quality of the assumed friction factor model.

QUESTION 7:

A multinomial logit model has been calibrated for modal share for all trips to a specific destination area. Three alternative modes, including auto (single occupancy), carpool and transit, are considered with the following utility functions:

$$V_m = B_m - 0.05\, T_m - 0.25\, C_m$$

Where V_m is the utility towards mode m, B_m is the mode specific constant, T_m and C_m are travel time (min) and travel cost ($) for mode m, respectively. A total 10,000 person trips are expected to come to this destination. The mode attributes for this O-D pair are as follows:

Mode m	B_m	Travel Time T_m (min)	Travel Cost C_m (dollars)
Auto	2.10	15	$2.50
Carpool	1.20	20	$1.00
Transit	0.00	30	$0.75

a) What is the mode share for trips to this destination?

b) If an additional parking fee of $2 is charged at this destination for each parking space, how many parking spaces could be reduced? You can assume that the average occupancy of carpool trips is 2.5 persons per vehicle and that the parking fee splits equally among all carpool travelers.

c) What is the cross elasticity of the transit demand with respect to auto travel cost? (An approximate solution such as shrinkage ratio is acceptable).

Marking scheme:

Question	Sub-questions	Marks
1	a) b) c)	8 8 4
2	a) b)	10 10
3	a)-e)	4 each
4	a) b)	16 4
5	a) b)	10 10
6	a) b)	12 8
7	a) b) c)	8 6 6