NATIONAL EXAMINATION MAY 2011

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 difference between a supply-side solution and a demand-side solution for transportation problems. Provide one example for each.

(b) Explain how the interaction between land use and transportation occurs and why it is important for predicting the growth of travel.

(c) Describe why trip length distribution and time-of-day variation of trip generation are usually different for different trip purposes. Provide an example for each.

QUESTION 2:

Suppose you observed vehicle arrival flows at a single-lane approach of a signalized intersection for two consecutive cycles. The arrival rate was 1080 veh/hour in the first cycle and it decreased to 720 veh/hour in the second cycle. Assume that the vehicles in the queue formed during the red interval cleared during the subsequent green interval at the saturation flow rate of 1800 veh/hour immediately after the start of the green interval. The signal has a cycle time of 60 seconds with a 30 second green interval and a 30 second red interval (for the sake of this question, you can ignore the yellow interval).

(a) Sketch a queueing diagram (cumulative arrival and departure curves over time) and determine the time when the queue cleared.

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

(c) Calculate 1) the total vehicle delay and 2) the average delay per vehicle for vehicles arriving during the two cycles.

The following table shows the number of households (HH) and the number of trips produced from each household type (categorized by household size and automobile ownership) obtained from a household travel survey.

	Automobile ownership					
	0		1		2 or more	
Household size	No. of HH	No. of Trips	No. of HH	No. of Trips	No. of HH	No. of Trips
1	28	3	21	20	25	30
2	150	90	201	277	93	201
3	61	57	90	131	75	183
4 or more	37	38	142	240	90	234

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

Forecasted number of households

	Automobile ownership		
Household size	0	1	2 or more
1	40	25	30
2	172	222	134
3	80	101	89
4 or more	53	157	120

(a) Calculate the forecasted number of trips for each household type for a target year.

(b) Alternatively, the household based travel survey data were used to calibrate the following linear regression equation for the expected trip generation rate by a household:

Trip rate = -0.16 + 0.33 * HSIZE + 0.72 * AUTO

where
HSIZE = household size;
AUTO = automobile ownership.

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 limitations.

QUESTION 4:

Traffic flow on a single-lane road with no passing lane has a free-flow speed of 60 km/hour and a jam density of 144 vehicles/km.

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

(b) At a particular time of a day, the traffic on this road is flowing at a density of 36 vehicles/km. A truck with a speed of 10 km/h enters the road, travels for 1.6 km and exits the road. The cars immediately behind the truck are forced to lower their speed. Using the shock wave theory, determine the length of the platoon after the truck exits the highway.

(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 road downstream of the exit point of the truck.

QUESTION 5:

New industrial facilities are planned at a vacant site. It is expected that the facilities will create jobs and attract the people to the four neighboring residential zones 1, 2, 3 and 4. As a result, the numbers of daily trips produced from zones 1, 2, 3 and 4 will increase to 1200, 1500, 1000 and 1700, respectively. Assume that the total trip attraction to the facilities from the four zones is 500 trips per day. The travel distances from zones 1, 2, 3 and 4 to the facilities are 7.5 km, 5 km, 10 km and 12.5 km, respectively.

(a) Estimate the number of trips from zones 1, 2, 3 and 4 to the facilities using the gravity model. Assume that a friction factor is inversely proportional to the travel distance from an origin zone to the facilities.

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

(c) Discuss the limitations of the gravity model.

QUESTION 6:

There are two major routes from the zone A to the zone B – Route 1 and Route 2. The travel time on each route can be estimated using the following volume-delay functions:

$$t_1 = 14 + 2\left(\frac{V_1}{1200}\right), \quad t_2 = 15 + \frac{V_2}{1400}$$

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. Total hourly volume from the zone A to the zone B is 5,000 vehicles/hour.

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

(b) The new route - Route 3 - has been added to reduce the travel times on Routes 1 and 2. Route 3 does not overlap with Routes 1 and 2. This new route has the following volume-delay function:

$$t_3 = 16 + 0.5\left(\frac{V_3}{1400}\right)$$

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 for work trips. There are three available modes of travel (auto, bus and light rail). The observable utility functions were specified as follows:

Auto: $V_a = 0.73 - 0.47 \cdot TC_b - 0.22 \cdot TT_a$
Bus: $V_b = 0.38 - 0.47 \cdot TC_b - 0.22 \cdot TT_a$
Light rail: $V_r = - 0.47 \cdot TC_b - 0.22 \cdot TT_a$

where,
V_i = observable utility for mode i ;
TC_i = travel cost for mode i (\$);
TT_i = travel time for mode i (minutes).

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

Mode	TC	TT
Auto	\$2.00	10 min
Bus	\$0.75	18 min
Light rail	\$1.25	15 min

(b) The auto mode is now classified into two different modes – auto-drive (drive alone) and auto-passenger (shared ride or carpool). Assume that the travel time for both modes is equal (= 10 min.) and the travel costs of auto-driver and auto-passenger are \$2.00 and \$1.00, respectively. Calculate the shares of the four modes using a multinomial logit model.

(c) Does the result in (b) make intuitive sense? Comment on the result based on the independent of irrelevant alternatives (IIA) property of the multinomial logit and suggest how to overcome the limitations of the IIA property in this mode choice problem.