Department of Civil Engineering
INDIAN INSTITUTE OF TECHNOLOGY DELHI
CEL 442: TRAFFIC AND TRANSPORTATION PLANNING

Major **Maximum Marks: 60; Time: 2 hr** **29th November 2006**

*Instructions: i) Answer **ALL** the questions, ii) Some useful formules are given at the end, iii) Draw graphs/figures wherever necessary, end iii) Assume any data required suitably*

Question 1 (3×5 = 15 marks)

a) Discuss briefly on the evolving perspective of transportation planning and decision-making process.

b) Derive the formula for incremental logit model.

c) Two roads begin at a gate entrance to a park and take different scenic routes to a single main attraction in the park. 4000 vehicles arrive during the peak hour, and the traffic distributes among the two routes so that an equal number of vehicles take each route. The performance functions for the routes are $t_1 = 10+x_1$ and $t_2 = 5+3x_2$, where x represents thousands vehicles per hour and the t's in minutes. How many vehicle hrs would have been saved had the vehicular traffic distributed so as to achieve a system-optimality.

Question 2 (15 marks)

a) A 3-lane freeway drops a lane at location $x = 0$ km. If the maximum flow per lane is 1,800 veh/h, the jam density per lane is 108 veh/km, and the free flow speed is 100 km/h, then, plot to scale on a single set of axes the *q* vs. *k* relations for the 3-lane and 2-lane sections of the road, as well as the curve corresponding to a single lane. Assume that the *q-k* curve(s) are smooth and explain i the geometrical feature that relates the three curves. (5)

b) Perform a chi-squared test on a shifted negative exponential headway distribution, for a flow with 300 veh/h and a minimum time headway of 2.0 secs. Plot the data. (10)

Question 3 (15 marks)

a) Traffic is moving on a one-way road at q_A = 1000 veh/h, k_A = 16 veh/km/. A truck enters the stream at point P (which is at a distance of 1 km from an upstream point) at a speed of 16 km/h/. Due to the entry of truck, the density behind decreases to 75 veh/km. After 10 minutes, the truck leaves the stream. The platoon behind the truck then releases itself at the capacity conditions, q_C = 1400 veh/h and k_C = 44 veh/km. Determine the speed of all the shockwaves generated. (7)

b) Suppose that q(t, x) and k(t, x) on a one-directional road are given by the following: $q(t,x) = q_0 e^{(t/t_0 - x/x_0)}$; $k(t,x) = k_0 e^{(t/t_0 - x/x_0)}$ Identify whether this formula is physically possible, without traffic generation in the vicinity of (t_0, x_0). If it is physically possible, determine N (t,x) and explain qualitatively what is happening? (8)

Question 4 (15 marks)

a) What do you understand by dynamic traffic assignment? Discuss in detail the analytical and simulation based approaches. (6)

b) From the generalized car following model for the values of l =2; m = 1, prove that the underlying macroscopic speed density relationship is, $v = v_f \exp(-k/k_0)$ (Underwood's Model), where k_0 is the density at maximum flow. (9)

Some useful formulas:

$$\min \quad S(x) = \sum_n x_n t_n(x_n)$$

$$P(h \geq t) = e^{-(t-\alpha)/(\bar{t}-\alpha)}$$

$$v_w = \frac{q_d - q_u}{k_d - k_u}$$

$$\frac{\partial k(t,x)}{\partial t} + \frac{\partial q(t,x)}{\partial x} = 0$$

$$a_{n+1}(t+\Delta t) = \frac{\alpha_{l,m}(v_{n+1}(t+\Delta t))^m [v_n(t) - v_{n+1}(t)]}{(x_n(t) - x_{n+1}(t))^l}$$

	α									
df	0.995	0.990	0.975	0.950	0.900	0.100	0.050	0.025	0.010	0.005
1	0.0000393	0.000157	0.000982	0.00393	0.0158	2.71	3.84	5.02	6.64	7.88
2	0.0100	0.0201	0.0506	0.103	0.211	4.61	6.00	7.38	9.21	10.6
3	0.0717	0.115	0.216	0.352	0.584	6.25	7.82	9.35	11.4	12.9
4	0.207	0.297	0.484	0.711	1.0636	7.78	9.50	11.1	13.3	14.9
5	0.412	0.554	0.831	1.15	1.61	9.24	11.1	12.8	15.1	16.8
6	0.676	0.872	1.24	1.64	2.20	10.6	12.6	14.5	16.8	18.6
7	0.990	1.24	1.69	2.17	2.83	12.0	14.1	16.0	18.5	20.3
8	1.34	1.65	2.18	2.73	3.49	13.4	15.5	17.5	20.1	22.0
9	1.73	2.09	2.70	3.33	4.17	14.7	17.0	19.0	21.7	23.6
10	2.16	2.56	3.25	3.94	4.87	16.0	18.3	20.5	23.2	25.2
11	2.60	3.05	3.82	4.58	5.58	17.2	19.7	21.9	24.7	26.8
12	3.07	3.57	4.40	5.23	6.30	18.6	21.0	23.3	26.2	28.3
13	3.57	4.11	5.01	5.90	7.04	19.8	22.4	24.7	27.7	29.8
14	4.07	4.66	5.63	6.57	7.79	21.1	23.7	26.1	29.1	31.3
15	4.60	5.23	6.26	7.26	8.55	22.3	25.0	27.5	30.6	32.8
16	5.14	5.81	6.91	7.96	9.31	23.5	26.3	28.9	32.0	34.3
17	5.70	6.41	7.56	8.67	10.1	24.8	27.6	30.2	33.4	35.7
18	6.26	7.01	8.23	9.39	10.9	26.0	28.9	31.5	34.8	37.2
19	6.84	7.63	8.91	10.1	11.7	27.2	30.1	32.9	36.2	38.6
20	7.43	8.26	9.59	10.9	12.4	28.4	31.4	34.2	37.6	40.0
21	8.03	8.90	10.3	11.6	13.2	29.6	32.7	35.5	39.0	41.4
22	8.64	9.54	11.0	12.3	14.0	30.8	33.9	36.8	40.3	42.8
23	9.26	10.2	11.0	13.1	14.9	32.0	35.2	38.1	41.6	44.2
24	9.89	10.9	12.4	13.9	15.7	33.2	36.4	39.4	43.0	45.6
25	10.5	11.5	13.1	14.6	16.5	34.4	37.7	40.7	44.3	46.9
26	11.2	12.2	13.8	15.4	17.3	35.6	38.9	41.9	45.6	48.3
27	11.8	12.9	14.6	16.2	18.1	36.7	40.1	43.2	47.0	49.7
28	12.5	13.6	15.3	16.9	18.9	37.9	41.3	44.5	48.3	51.0
29	13.1	14.3	16.1	17.7	19.8	39.1	42.6	45.7	49.6	52.3
30	13.8	15.0	16.8	18.5	20.6	40.3	43.8	47.0	50.9	53.7
40	20.7	22.2	24.4	26.5	29.1	51.8	55.8	59.3	63.7	66.8
50	28.0	29.7	32.4	34.8	37.7	63.2	67.5	71.4	76.2	79.5
60	35.5	37.5	40.5	43.2	46.5	74.4	79.1	83.3	88.4	92.0
70	43.3	45.4	48.8	51.8	55.3	85.5	90.5	95.0	100.0	104.0
80	51.2	53.5	57.2	60.4	64.3	96.6	102.0	107.0	112.0	116.0
90	59.2	61.8	65.7	69.1	73.3	108.0	113.0	118.0	124.0	128.0
100	67.3	70.1	74.2	77.9	82.4	114.0	124.0	130.0	136.0	140.0

Source: Adapted from E. S. Pearson and H. O. Hartley, *Biometrika Tables for Statisticians*. Vol. I (1962), pp. 130–131. Reprinted by permission of the Biometrika Trustees.