National Exams December 2002

98-Civ-A6, Transportation Engineering and Planning

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 models or Sharp approved models.
3. This is a Closed-Book exam. One double-sided aid sheet is permitted.
4. Any five questions constitute a complete paper 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) A planned road improvement will require an initial investment of 150 million dollars now and a further investment of 135 million dollars after one year. The construction period will be two years from the initial investment to the entry into service of the improved road. The initial traffic during the first year of service will be 1699 vehicles per day, of which 12% will be trucks. The traffic is expected to grow at an annual rate of 4% and a service life of 20 years is planned. If the benefits resulting from the reduced journey length and improved alignment and surface condition are considered to be $30 per year per automobile and $90 per year per truck, calculate the net present worth of the project for a discount rate of 6%. Assume that costs are incurred at the beginning of the year and that benefits accrue at the end of the year.

(b) Briefly explain how the discount rate affects the present worth of a project.

QUESTION 2

For an urban road, the following relationship has been established:-

$$Q = 273V - 70\,V \ln V$$ where Q is the flow and V the speed.

(a) Calculate (i) the capacity (maximum flow), (ii) the speed at capacity, (iii) the density at capacity, (iv) the free flow speed and (v) the jam concentration

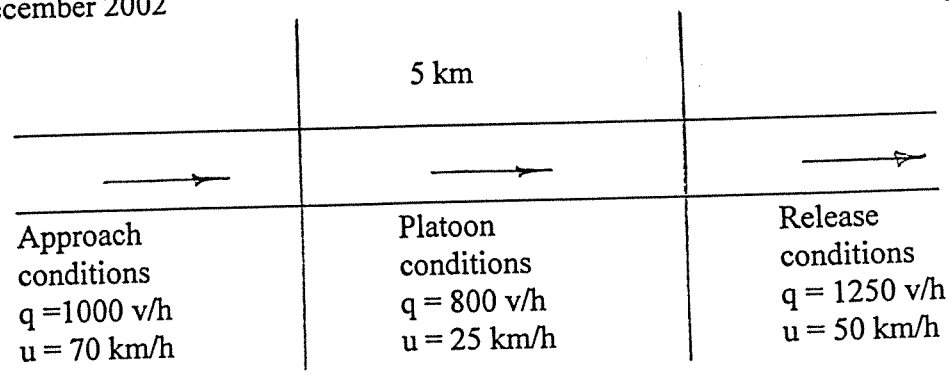
(b) Derive equations for density-flow and speed-density relationships and sketch them and the speed-flow relationship. Indicate the critical points on the sketches.

(c) Briefly explain what is meant by level of service and indicate the various levels on the speed flow curve.

QUESTION 3

Figure 3 shows the traffic conditions at time t_0 after a period of reduced speed operation in the vicinity of a school.

(a) Calculate how long it would take for the 5 km long platoon to dissipate and the speed of the shock wave which would commence at the moment when the platoon was completely dissipated.



(b) Briefly describe what is meant by a shock wave and explain how one is caused.

QUESTION 4

(a) Calculate the distance required for a vehicle to leave a freeway, whose design speed is 120 km/h, in safety and to enter an off-ramp whose design speed is 40 km/h. A rate of deceleration of 1.7 m/s^2 and a lateral speed of 1 m/s may be assumed. The required distance will consist of two parts, a taper permitting divergence from the freeway traffic and a braking section. State any assumptions you make and draw a dimensioned sketch of the layout.

(b) If the off-ramp slopes upwards at 4% calculate the effect on the length required.

(c) Briefly describe what is meant by ramp metering and why it might be used.

QUESTION 5

(a) Table 5.1 is a cross-classification table which shows the calibrated, non-work, home-based trip production rates for various types of household defined by household size, car ownership and residential density. Using the data given in Table 5, calculate the total non-work, home-based trip productions for the mixtures of households (hh) shown in Table 5.2

		Persons per household		
Area type	Vehicles per hh	1	2, 3	4
Urban high density	0	0.57	2.07	4.57
	1	1.45	3.02	5.52
	2 +	1.82	3.39	5.89
Suburban medium density	0	0.97	2.54	5.04
	1	1.92	3.49	5.99
	2 +	2.29	3.86	6.36
Rural low density	0	0.54	1.94	4.44
	1	1.32	2.89	5.39
	2 +	1.69	3.26	5.76

Table 5.1 Home-based, non-work trip rates

	Zone 1, urban			Zone 2, suburban			Zone 3, rural		
Cars/hh	0	1	2+	0	1	2+	0	1	2+
Persons/hh									
1	200	50	20	40	160	210	290	60	110
2,3	100	80	30	25	500	400	110	190	90
4	150	100	90	110	450	120	500	350	175

Table 5.2 Household composition

(b) Briefly explain the assumptions underlying the use of cross-classification models to predict future trip generation.

QUESTION 6

A zonal interchange is served by a local bus service and by an express bus service. The present travel times and fares for the two types of service are:-

	Travel time (min)	Fare $
Local	50	0.50
Express	30	1.00

Given the linear-arc elasticities of demand in Table 6 and that the current transit patronage of 4000 trips per peak period is split 40/60 between the express and local services, calculate:-

(a) the effect of raising the express bus fare to $1.50 and

(b) the effect of reducing the express bus travel time to 25 minutes.

(c) Define the price elasticity of demand. What is meant by a demand said to be price inelastic? Give an example of price inelastic demand.

	Local		Express	
	Time	Fare	Time	Fare
Local	-0.02	-0.03	+0.01	+0.02
Express	+0.09	+0.62	-0.08	-0.15

Table 6

QUESTION 7

(a) An origin-destination study in ten travel analysis zones provided the following data relating to zonal residential density and average daily trip productions per household. Calibrate and plot a model of the form $10^{Y} = a\,X^{-B}$

Density X	42	5	25	10	4	15	20	12	14	22
Trip rate Y	1.5	4.0	2.1	2.6	4.8	2.0	2.5	3.3	1.9	2.0

(b) Describe briefly the variables most likely to affect trip generation.

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